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Theme: Agriculture in Economic Growth and Stability

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JOURNAL
OF
FARM ECONOMICS

Volume XXXVIII AUGUST, 1956 Number 3

MEASUREMENT OF SUBSTITUTION IN DEMAND FROM TIME SERIES DATA—A SYNTHESIS OF THREE APPROACHES

KENNETH W. MEINKEN, ANTHONY S. ROJKO, AND GORDON A. KING*
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SINCE the days of Walras, at least, economists have recognized the importance of substitution in demand. Theoretically, the consumption of a commodity depends not only upon its own price, but also upon prices of all other commodities. The Walrasian formulation of the problem is too unwieldy for purposes of statistical measurement. Many statisticians, however, have measured the interrelationships among the demands for two or three commodities—neglecting the minor effects of other commodities and services. Thus, they have measured competition between beef and pork, without worrying too much about the undoubted fact that beef consumption may be slightly affected by the price of gasoline, shoes, and movie tickets.

Most of the statistical work done on this problem has been based either upon demand and cross elasticities, or upon the relation of consumption ratios to price ratios. Recently Waugh has derived a partial indifference surface from market data.[1] So far as we know, no statistical studies have compared and evaluated results obtained from demand functions, the relation of ratios, and an indifference surface. Morrissett explained the theoretical and mathematical relationships among these three measures, but did not apply his results to concrete statistical problems.[2]

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* Kenneth W. Meinken, formerly with the Agricultural Marketing Service, is Assistant Professor, Department of Agricultural Economics, Rutgers University. This paper was developed from research under authority of the Agricultural Marketing Act of 1946 (RMA, Title II). The authors wish to express their appreciation to Frederick V. Waugh, Richard J. Foote, Glenn L. Burrows, and Carroll Downey of the Agricultural Marketing Service for their assistance and valuable suggestions.

[1] Frederick V. Waugh, "A Partial Indifference Surface for Beef and Pork," *Journal of Farm Economics*, Vol. 38, February 1956, pp. 102-112.

[2] Irving Morrissett, "Some Recent Uses of Elasticity of Substitution—A Survey," *Econometrica*, Vol. 21, January, 1953, pp. 41-62.

Since the demand functions for two commodities, the relation of the consumption ratios to the price ratios, and the indifference function all involve the same variables—prices, quantities, and income—and provide measures that are designed to indicate the competitive relationship between two commodities, it appears, on an intuitive basis at least, that it would be possible by appropriate mathematical transformations to go directly from any given approach to the other two. We shall, in fact, show that it is possible to go directly from the demand functions to the ratios, or to the indifference surface, but it is not possible to go the other way. To illustrate this fact, we present here the demand functions for

TABLE 1. WHOLESALE PRICE AND CONSUMPTION OF BEEF AND PORK, AND CONSUMER INCOME, CANADA, 1928–53[1]

Year	Wholesale price per pound, (deflated)[1,2]			Consumption from inspected slaughter per capita[1]			Consumer income per capita (deflated)[3]
	Beef	Pork	Ratio of beef to pork	Beef	Pork	Ratio of beef to pork	
	Cents	*Cents*		*Pounds*	*Pounds*		*Dollars*
1928	23.68	23.12	1.024	29.79	29.85	0.998	618
1929	25.34	25.90	.978	29.91	29.79	1.004	604
1930	24.36	25.50	.955	29.65	27.08	1.095	558
1931	19.18	21.98	.873	29.56	26.27	1.125	515
1932	18.58	12.59	1.476	25.76	33.14	.777	463
1933	16.39	14.14	1.159	27.18	30.79	.883	444
1934	15.62	19.56	.799	31.38	28.27	1.110	483
1935	16.97	21.28	.798	32.70	25.94	1.261	507
1936	16.46	21.86	.753	36.14	27.22	1.328	519
1937	18.45	20.66	.893	36.62	32.05	1.143	565
1938	18.98	22.85	.831	35.51	28.50	1.246	559
1939	18.95	22.40	.846	35.00	27.83	1.258	591
1940	20.63	21.12	.977	35.43	30.24	1.172	643
1941	22.61	21.19	1.067	38.32	41.99	.913	699
1942	23.56	24.91	.946	40.76	42.16	.967	822
1943	24.87	24.87	1.000	40.94	43.35	.944	853
1944	26.77	25.44	1.052	44.84	62.62	.716	914
1945	26.74	25.40	1.052	50.01	51.79	.966	927
1946	27.13	25.92	1.047	56.75	33.92	1.673	940
1947	26.61	27.19	.979	51.36	32.97	1.558	900
1948	31.04	33.07	.939	46.50	41.52	1.120	890
1949	39.04	35.28	1.107	43.52	42.26	1.030	876
1950	42.21	32.67	1.292	40.14	45.79	.877	890
1951	47.16	35.28	1.337	36.14	47.45	.762	922
1952	43.05	27.23	1.581	42.31	53.91	.785	937
1953	32.90	29.68	1.108	46.40	51.04	.909	976

[1] Price and consumption data are for the first three quarters of the year indicated plus the last quarter of the previous calendar year. Income data are for the calendar year indicated.

[2] Average wholesale carcass price at Toronto, deflated by the Canadian consumer price index, 1949=100 (an estimated deflation factor was used for years prior to 1935, for which monthly price indexes were not published, based on the Canadian annual price index and the consumer price index for the United States).

[3] Deflated by the Canadian consumer price index, 1949=100.

Source: Marketing Service, Economic Division, Canadian Department of Agriculture.

beef and pork, the relation of the consumption ratios to the price ratios, and a partial indifference surface, each derived from Canadian data. A statistical analysis relating to consumption ratios and price ratios for the Canadian data has been published by Woollam.[3]

The data used in these analyses are shown in Table 1. We selected these data to illustrate the interrelationship of the three approaches, as the competitive relationship of beef and pork in Canada approaches a special case of symmetry. The years included in the analyses are 1928-41, 1948-51, and 1953. The war years are excluded because of price controls, and 1952 is excluded because support operations were in effect for beef and pork in Canada and the ban on interprovincial shipments of beef due to an outbreak of hoof and mouth disease also seriously distorted price relationships. Price and consumption data are for a marketing year beginning October and income is on a calendar year basis.[4]

Empirical Demand Functions

Demand theory conventionally specifies that, for an individual consumer, the quantity of beef or pork consumed depends upon prices of beef, pork, and all other commodities, the individual consumer's income, and factors that reflect changes in tastes and preferences. Market demand, which is the summation of these individual demands, may be defined as follows:

$$Q_b = f(P_b, P_p, Y, u_1) \qquad (1.0)$$

$$Q_p = f(P_b, P_p, Y, u_2) \qquad (2.0)$$

where the Q's represent the aggregate consumption of beef (Q_b) and Pork (Q_p), the P's represent market prices of beef (P_b) and pork (P_p); Y represents aggregate consumer income; and the u's represent random disturbances that affect consumption of beef and pork. As no separate allowance is made for substitute commodities such as other meats and fish, the u's also include the effect of changes in the price or supply of these. Other meats and fish are believed to be relatively unimportant in affecting the quantity of beef and pork consumed.

If time series data on prices, quantities and incomes are given, the method used to estimate the coefficients in these demand relations depends on assumptions that are made regarding the type of functional relation that generates the observed data. For beef and pork, as for many other agricultural commodities, production and consumption in any given

[3] T. G. E. Woollam, "The Influence of Prices on the Relative Consumption of Beef and Pork," *The Economic Annalist*, Canadian Department of Agriculture, Vol. 23, April 1953, pp. 29-32.

[4] The series on Canadian disposable income, except for recent years, is available only on a calendar year basis.

period are essentially predetermined, i.e., the supply curve is completely or almost completely inelastic. Figure 1 illustrates more clearly the nature of the relationships believed to exist. When consumption of two competing agricultural commodities can be assumed for all practical purposes to be independent of prices in the current period, the procedure normally has been to estimate the coefficients for the relations that express the

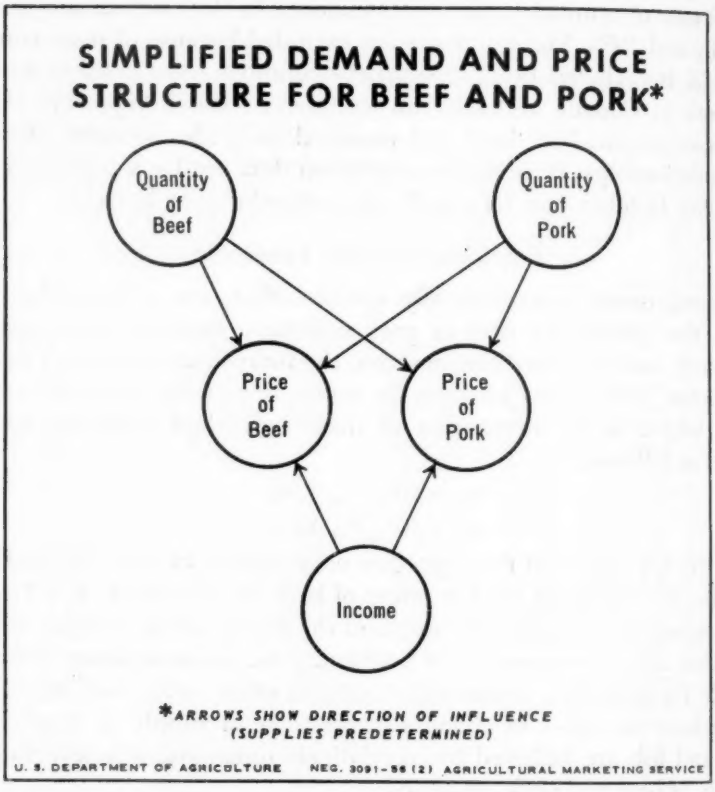

FIG. 1. A DIAGRAM SHOWING THE MAJOR FACTORS THAT AFFECT PRICES OF BEEF AND PORK.

price of each good as a function of the two quantities and income. This procedure gives biased results when applied to two or more competing commodities because, as indicated in Figure 1, prices for each commodity are simultaneously determined by the interaction of demand factors and the supply of each.[5] Thus a given combination of production of beef and pork results in a unique set of market prices that is si-

[5] Structural coefficients that are statistically consistent for agricultural commodities that are independent (i.e. that have no close substitutes and no close complements) and for which consumption is essentially predetermined can be ob-

multaneously determined. To obtain estimates of the elasticities of demand that are statistically consistent, the parameters in the structural demand equations (1.0) and (2.0) must be estimated by a statistical method that allows for this simultaneity. Equations of the sort discussed here always are just identified. Hence, the reduced-form method of fitting simultaneous equations can be used to estimate the coefficients.[6]

Data shown in Table 1 were converted to logarithms and were used in the reduced-form analysis. Prices and income were expressed in constant dollars. The estimates of the coefficients in the reduced-form equations that are used to compute structural demand coefficients in this and subsequent demand analyses are shown in Note 1. The resulting structural equations are shown below. Figures in parentheses are standard errors of the regression coefficients computed by a method suggested by Klein.[7]

$$\log Q_b = -1.85 - \underset{(.18)}{0.88 \log P_b} - \underset{(.18)}{0.02 \log P_p} + \underset{(.31)}{1.65 \log Y} \qquad (3.0)$$

$$\log Q_p = -1.85 + \underset{(.23)}{0.04 \log P_b} - \underset{(.23)}{1.03 \log P_p} + \underset{(.39)}{1.69 \log Y} \qquad (4.0)$$

---

tained directly (1) by fitting a least squares regression equation where price is the dependent variable and supply and consumer income are independent variables, and (2) by making a direct algebraic transformation to derive the coefficients of elasticities. This approach is permissible under these circumstances but not in the case discussed in the text because, for items that are independent for all practical purposes, only a single structural equation is involved. For a discussion of the conditions under which this approach can be used see Karl A. Fox, *The Analysis of Demand for Farm Products*, U. S. Dept. Agr., Tech. Bul. 1081, 1953, pp. 9-12.

[6] The computational procedure used can be summarized in three steps: (1) Algebraically recombine and rearrange the variables in the structural demand equations in such a manner that each of the jointly determined variables (P_b and P_p) is expressed separately as a function of all the predetermined variables (Q_b, Q_p and Y) appearing in the structural equations of the system. (2) Fit these equations (commonly known as reduced-form equations) by ordinary least squares method. The estimates for these equations are shown in Note 1. (3) Compute algebraically the structural demand coefficients from the estimates obtained in (2) above. Step 3 is essentially the reverse of step 1. The algebraic relationships between the demand coefficients and the "flexibility" coefficients in price-estimating (reduced-form) equations are shown in Note 1. For a more detailed discussion of the reduced-form method, see Richard J. Foote, "A Comparison of Single and Simultaneous Equation Techniques," *Journal of Farm Economics*, Vol. 37, Proceedings Issue, December 1955, pp. 975-990. Another approach for estimating coefficients in just identified equations is described in detail by Joan Friedman and Richard J. Foote, *Computational Methods for Handling Systems of Simultaneous Equations*, U. S. Dept. Agr. Agricultural Handbook 94, 109 pp., 1955. However, estimates of the standard errors of the structural coefficients cannot be obtained when the method suggested by Friedman and Foote is used in those cases for which a *predetermined* variable is to be written in the structural equations as a function of other variables in the analysis. It is primarily for this reason that the reduced-form approach is used in this paper.

[7] Lawrence R. Klein, *A Textbook of Econometrics* (Evanston, Ill. and White Plains, N.Y.: Row, Peterson and Co., 1953), pp. 258-259.

Similar analyses, assuming linear relationships of actual data (deflated), indicate demand elasticities for beef of −0.76 with respect to the price of beef, +0.07 with respect to the price of pork and +1.44 with respect to real income, and, for pork, of −1.12 with respect to the price of pork, +0.18 with respect to the price of beef, and +1.56 with respect to real income when computed at the means of the several series. As in the logarithmic formulation, the cross elasticities are not statistically significant.

When time is included as a variable in the analysis based on linear relationships of actual data, the results are as follows:

$$Q_b = 14.38 - \underset{(.19)}{0.88P_b} + \underset{(.31)}{0.33P_p} + \underset{(.019)}{0.047Y} + \underset{(.19)}{0.35T} \qquad (3.1)$$

$$Q_p = 12.90 + \underset{(.28)}{0.25P_b} - \underset{(.45)}{1.57P_p} + \underset{(.027)}{0.082Y} + \underset{(.28)}{0.09T} \qquad (4.1)$$

where quantities are in pounds per person, prices in cents per pound, and annual income in dollars per person (prices and income in 1949 dollars).

The demand elasticities, evaluated at the mean values, for the beef equation (3.1) are −0.62 with respect to the price of beef, +0.23 with respect to the price of pork and +0.87 with respect to real income. For the pork equation (4.1), similar demand elasticites are −1.12 with respect to the price of pork, +0.18 with respect to the price of beef, and +1.56 with respect to real income. The inclusion of time as a variable materially affected the demand elasticities for beef but not those for pork. When time was included in the analysis based on logarithms, similar results were obtained. However, the changes in the demand elasticities for beef, although in the same direction, were not as pronounced as in the analysis based on actual data. For beef, the inclusion of time in the logarithmic analysis changed the direct-price elasticity from −0.88 to −0.73; the income elasticity from +1.65 to +1.30; and the cross-price elasticity from −0.02 to +0.08.

Previous analyses for the United States and other countries suggest that equation (3.1) seems to give the most reasonable coefficients for beef. On the whole, the income coefficients were higher than expected. Since real income trended upward during this period, the income coefficient possibly may reflect some of the trend in consumption resulting from the effect of factors other than income. This is suggested by the considerable reduction in the income coefficient for beef when time is included as a variable. It should be noted that the consumption data used in this analysis are based on inspected slaughter. For the period

1935-39, inspected slaughter of cattle accounted for about two-thirds of the total slaughter compared with about three-fourths in the postwar years included in the analysis. However, for hogs, about two-thirds of the total slaughter was inspected in both periods.

Because most of the variables in the postwar years were substantially larger than in the prewar years, a check was made to determine the influence on demand coefficients of including the postwar years in the analysis. An analysis based on logarithms for 1928-41 showed some changes in the estimates of demand coefficients. However, the magnitude of these changes was not considered large enough to warrant separate analyses for the two periods.

When residual errors in the price-estimating equations in Note 1 were plotted against time, no consistent trend was found in the residuals. However, a comparison of estimated prices with actual prices indicates that cyclical movements of cattle and hog supplies may exert some influence not specified in the model.

Elasticity of Substitution

Various research workers have derived statistical estimates of the elasticity of substitution (E_s) by a short-cut method of relating price ratios and consumption ratios. We show here that the estimate so derived is a true estimate of E_s only under very restrictive conditions that are unlikely to hold. The example we select is one for which these restrictive conditions are met fairly well. It should be emphasized that this is an exception—similar data for the United States do not give these relationships. Furthermore, we point out reasons why E_s, defined as a measure of the "ease" of substitution along an indifference curve, is not a particularly useful concept in the consideration of demand interrelationships.

The type of demand interrelationship between beef and pork implied by the following equation has been used in many comparable studies to obtain a value for λ which has been described as the elasticity of substitution, E_s.[8]

$$\log \frac{Q_b}{Q_p} = K + \lambda \log \frac{P_b}{P_p} \qquad (5.0)$$

Morrissett, in an excellent article, clarified the meaning and use of E_s, and presented the conditions that must hold for the coefficient λ to equal the elasticity of substitution.[9]

---

[8] The introduction of the concept of the elasticity of substitution is credited to J. R. Hicks in *The Theory of Wages* (London: Macmillan and Co., Ltd., 1932), p. 117 and appendix. See Morrissett, *op. cit.*, footnote on p. 54.

[9] I. Morrissett, *op. cit.* He lists works of writers concerned with the development and interpretation of this concept on pages 61-62.

Admitting community or market indifference curves for this discussion of demand interrelationships, E_s can be thought of as a measure of how easily the proportion of beef to pork consumption changes as we move along an indifference curve. It measures the ratio of the proportionate change in the ratio of the quantity of beef to pork consumed to a given proportionate change in the ratio of their marginal utilities (or the marginal rate of substitution of beef for pork). Mathematically, E_s may be defined as

$$\frac{d\ (Q_b/Q_p)}{d\ (dQ_p/dQ_b)} \cdot \frac{dQ_p/dQ_b}{Q_b/Q_p} \tag{6.0}$$

where dQ_p/dQ_b is the marginal rate of substitution of beef for pork, and the factor $dQ_p/dQ_b/Q_b/Q_p$ is introduced to make E_s independent of the units of measurement of Q_b and Q_p. Morrissett refers to (6.0) as the "basic" definition of E_s which, in terms of logarithms, becomes:

$$\frac{d \log\ (Q_b/Q_p)}{d \log\ (dQ_p/dQ_b)} \tag{6.1}$$

If we wish to measure E_s by reference to observed behavior, we must use actual market prices and quantities. In competitive equilibrium the ratio of marginal utilities of beef and pork equals the ratio of prices of beef and pork; i.e., $(\partial U/\partial Q_b)/(\partial U/\partial Q_p) = P_b/P_p$, where U is a utility index. Further, if movement is restricted to an indifference curve, changes in the consumption of beef must be offset by changes in the consumption of pork such that total utility remains the same, or $(\partial Q_b)(\partial U/\partial Q_b) + (\partial Q_p)(\partial U/\partial Q_p) = 0$. Thus the slope of the indifference curve equals the ratio of marginal utilities; i.e., $\partial Q_p/\partial Q_b = -(\partial U/\partial Q_b)/(\partial U/\partial Q_p)$. From these relations, it follows that $\partial Q_p/\partial Q_b = -P_b/P_p$, if equilibrium exists. If we substitute in both the numerator and denominator of equation (6), and assume that all other factors are held constant, we get

$$E_s = \frac{d(Q_b/Q_p)}{d(P_b/P_p)} \cdot \frac{P_b/P_p}{Q_b/Q_p} \tag{7.0}$$

The equivalent formula in terms of logarithms is:

$$E_s = \frac{d \log\ (Q_b/Q_p)}{d \log\ (P_b/P_p)} \tag{7.1}$$

The elasticity of substitution, as defined in (7.0), is referred to by Morrissett as the "empirical" definition. If equation (5.0) is used to estimate E_s, the definition (7.1) is implicit in the empirical estimates of E_s.[10] This follows because the value of the first derivative of (5.0),

[10] This approach has been used recently in the analysis of demand interrelationships for agricultural commodities by several research workers, such as Robert W. Rudd and D. Milton Shuffett, *Demand Interrelationships Among Domestic Cigarette*

[i.e., the coefficient λ obtained by differentiating $\log (Q_b/Q_p)$ with respect to $\log (P_b/P_p)$] is equivalent to the definition of E_s given in (7.1). Obviously, λ in equation (5.0) [and E_s in (7.1)] also equal the "basic" definition of (6.1) if the community remains on the same indifference curve. For this to be true, real income and all other factors must remain constant.

Is it possible to estimate a true E_s [i.e., λ] from equation (5.0) without restricting substitution possibilities between beef and pork to a given indifference curve? With given observations of price and quantity data, we have no reason to assume that the data were generated by a community that remained on a given indifference curve. Thus, an estimate of E_s from observed data using equation (5.0) may reflect changes in income and effects of other commodities. If there are side effects, it is clear that the total derivative [i.e., the empirical estimate of E_s] of a simplified estimating equation such as (5.0) is *not* appropriate. What is needed is a partial derivative of an estimating equation that specifies the other influencing variables; that is,

$$\lambda = \frac{\partial \log Q_b/Q_p}{\partial \log P_b/P_p} \tag{7.2}$$

where λ is an empirical estimate of E_s.

Naturally, the partial derivative equals the total derivative if there are no side effects. But, in addition, the partial derivative equals the total derivative even though the community does not stay on the same indifference curve *if* the income effects on beef and pork consumption are equal and there are no differential effects of other factors. This is shown more clearly in the following development.[11]

Suppose the demand functions for beef and pork specified by equations (1) and (2) are of the following form:

$$Q_b = AP_b^B P_p^C Y^D \tag{8.0}$$

$$Q_p = EP_b^F P_p^G Y^H \tag{9.0}$$

Tobaccos, Kentucky Agr. Exp. Sta. Bul. 633, June 1955; Kenneth W. Meinken, *The Demand and Price Structure for Oats, Barley, and Sorghum Grains*, U. S. Dept. Agr. Tech. Bul. 1080, Sept. 1953; T. G. F. Woollam, *op. cit.*; James N. Morgan, "Consumer Substitutions Between Butter and Margarine," *Econometrica*, Vol. 19, January 1951, pp. 18-39; and Marion Clawson, "Demand Interrelations for Selected Agricultural Products," *Quarterly Journal of Economics*, Vol. 57, February 1943, pp. 265-302. The limitations of the usefulness of this method were indicated in the *Journal of Farm Economics* by Adolf Kozlik, "An Investigation of Complementarity Relations Between Fresh Fruits: A Reply," *Journal of Farm Economics*, Vol. 23, August 1941, pp. 654-56; and by Sidney Hoos, "An Investigation of Complementarity Relations Between Fresh Fruits: A Rejoinder," *Journal of Farm Economics*, Vol. 24, May 1942, pp. 528-29. Also, various other writers have questioned the validity and usefulness of this approach.

[11] We are particularly indebted to Morrissett, *op. cit.*, for the theoretical development of the relationships presented in this section.

Expressing equations (8.0) and (9.0) in logarithmic form and taking the total differential, we get

$$d \log Q_b = B(d \log P_b) + C(d \log P_p) + D(d \log Y) \tag{10.0}$$

$$d \log Q_p = F(d \log P_b) + G(d \log P_p) + H(d \log Y) \tag{11.0}$$

where

$$B = \frac{\partial \log Q_b}{\partial \log P_b}, \quad C = \frac{\partial \log Q_b}{\partial \log P_p},$$

etc., i.e. the partial derivatives. These are the direct and cross price elasticities and income elasticities.

Subtracting (11.0) from (10.0) we get,

$$d \log Q_b - d \log Q_p = (B - F)\, d \log P_b - (G - C)\, d \log P_p + (D - H)\, d \log Y \tag{12.0}$$

Now suppose that in the determination of E_s, λ has been estimated by the least squares method from the equation

$$\log \left[\frac{Q_b}{Q_p}\right] = K + \lambda \log \left[\frac{P_b}{P_p}\right] + \mu \log Y \tag{13.0}$$

where the effect of income is explicitly accounted for just as is done in any least squares demand analysis. Taking the total differential of (13.0) we find that

$$d \log \left[\frac{Q_b}{Q_p}\right] = \lambda d \log \left[\frac{P_b}{P_p}\right] + \mu d \log Y \tag{14.0}$$

where λ equals the partial derivative specified in (7.2).

← Equation (14.0) can be rewritten so that

$$d \log Q_b - d \log Q_p = \lambda(d \log P_b) - \lambda(d \log P_p) + \mu d \log Y \tag{14.1}$$

From a mathematical standpoint, equations (12.0) and (14.1) are identical. Therefore, equating the coefficients in these two equations, we find that

$$\begin{aligned} &(a)\ \lambda = B - F = E_{bb} - E_{pb} \\ &(b)\ \lambda = G - C = E_{pp} - E_{bp} \\ &(c)\ \mu = D - H = E_{by} - E_{py} \end{aligned} \tag{15.0}$$

where λ and μ represent the elasticity of substitution and income effect, respectively, from equation (14.1); and E_{bb} and E_{pp} represent the direct elasticity of demand from equations (8.0) and (9.0) [and (12.0)], E_{bp} and E_{pb}, the cross elasticities, and E_{by} and E_{py}, the income elasticities since the coefficients B, C, etc., are from demand equations in logarithmic form.

The equalities expressed in (15.0) all follow from the implicit assumption that the elasticity of substitution is *constant* throughout all ranges

of substitution, and that any differential income effect is also constant. If other commodities did, in fact, influence consumption of beef or pork to a measurable extent, and were included explicitly in equations (8.0), (9.0), and (13.0), relationships of the following form would be added to (15.0):

$$(d)\quad \nu = E_{bi} - E_{pi} \tag{15.0}$$

for the ith commodity.[12]

As was stated earlier, if an equation such as (13.0) included explicitly all the factors affecting Q_b/Q_p, the estimated value of the partial derivative (λ) equals the true E_s, providing beef and pork are, in fact, close substitutes. The relations (c) and (d) in (15.0) are of particular interest because they provide clues as to the assumptions needed to permit the use of a simplified equation such as (5.0) to estimate a true E_s. If the assumption is made that real income and the consumption of the ith commodity remain constant (i.e., that the community stays on the same indifference curve), equation (5.0) always gives a true estimate of E_s.

But (5.0) also gives a true estimate of E_s, even though movement is not restricted to a given indifference curve, if changes in real income have no differential effect on consumption of beef and pork. Explicitly, in equation (13.0), the partial derivative with respect to log Y must equal zero, i.e.

$$\frac{\partial \log (Q_b/Q_p)}{\partial \log \ \iota} = 0$$

This, in effect, means that the income elasticities of beef and pork must be equal, i.e.

$$\frac{\partial \log Q_b}{\partial \log Y} = \frac{\partial \log Q_p}{\partial \log \ \iota}$$

This implies for (15.0) (c) that $\mu = D - H = E_{by} - E_{py} = 0$. Likewise, for the ith commodity, based on the same reasoning, if $\nu = E_{bi} - E_{pi} = 0$ in relation (15.0) (d), there is no differential effect from the ith commodity. In summary, the above conditions with respect to the ith commodity and income mean that

$$\frac{d \log [Q_b/Q_p]}{d \log [P_b/P_p]} = \frac{\partial \log [Q_b/Q_p]}{\partial \log [P_b/P_p]}$$

or the total derivative equals the partial derivative. Under those circumstances, the total derivative of equation (5.0) is equivalent to (7.1) and also to (6.1), the "basic" definition.

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[12] Demand equations (8.0) and (9.0) then become:

$$Q_b = AP_b^{\ B}P_p^{\ C}P_i^{\ M}Y^D$$
$$Q_b = EP_b^{\ F}P_p^{\ G}P_i^{\ N}Y^H$$

Several limitations in the measurement of E_s are imposed by the equality explicit in (15.0) (a) and (b); namely,

$$E_s = \text{constant} = \lambda = E_{bb} - E_{pb} = E_{pp} - E_{bp} \qquad (16.0)$$

The mathematical development of these relations assumes constant elasticities in the demand relations, but (16.0) also applies if demand elasticities are variable *providing* E_s remains constant and the effect of the ith commodity is zero for all beef and pork substitution possibilities.

Whenever values of the direct and cross (price) elasticities satisfy the equality in (16.0), equations relating quantity ratios and price ratios are apt to give a good fit. Although the mathematical relations imposed by (16.0) are necessary under the assumed model, they are not sufficient to assure us a measurement of E_s. By definition, E_s is a measure of the ease of substitution between two goods. But it is possible to maintain the equality in equation (16.0) if $E_{bb} - E_{pb} = E_{pp} - E_{pb}$ and to obtain an E_s of say -2.0 for goods that are independent (cross elasticities are zero), for goods that are competing–substitutes—(cross elasticities are positive), or for goods that are completing–complements–(cross elasticities are negative). This is illustrated as follows:

1. Independent goods $E_s = E_{11} - E_{21} = [-2.0 - (0)] = -2.0$
2. Substitutes $E_s = E_{11} - E_{21} = [(-1.0) - (+1.0)] = -2.0$
3. Complements $E_s = E_{11} - E_{21} = [(-3.0) - (-1.0)] = -2.0$

Thus, use of data for independent or complementary goods might give a good fit in equation (5.0) or (13.0), which relates price ratios to consumption ratios, and the regression coefficient will not necessarily tell us whether goods are independent, substitutes or complements. A further difficulty comes in interpreting different values of E_s, assuming the values are, in fact, the true values of the elasticity of substitution. E_s is not a simple concept, like the elasticity of demand, by which demand coefficients are put in standard units. It is a coefficient the value of which depends upon the direct price elasticities and cross price elasticities, as illustrated above. Income elasticities and supply elasticities also may enter in certain cases. It is possible to obtain an E_s, for example -3.0, for various sets of two substitutes that have very different demand structures, as shown below:

1. $E_s = E_{11} - E_{21} = [(-2.7) - (+0.3)] = -3.0$
2. $E_s = E_{11} - E_{21} = [(-1.5) - (+1.5)] = -3.0$

Furthermore, it is impossible to interpret a coefficient of -3.0 as indicating that two goods have a definite pattern of substitution (constant) which is "easier" than for a set of goods having an E_s of -2.0.

In view of these considerations, the statistician would do well to start

a demand investigation by obtaining estimates for coefficients in equations similar to (3.0) and (4.0). If these equations indicate differential income effects or differential effects from other substitute commodities or other factors, they immediately show that E_s cannot be estimated from equations like (5.0). Furthermore, the cross elasticities in these equations should directly indicate whether the commodities are substitutes, complements, or independent in demand, although it is realized that the equations for beef and pork shown on pp. 715-16 are not very conclusive

TABLE 2. STATISTICAL ESTIMATES OF ELASTICITIES OF SUBSTITUTION AND RELATED COEFFICIENTS FROM DEMAND FUNCTIONS AND ESTIMATES OF COEFFICIENTS FROM CONSUMPTION-RATIO PRICE-RATIO FUNCTIONS

Demand functions						Consumption-ratio price-ratio functions			
Equation number	Point of estimation of elasticities	Estimated value[1]				Equation number	Estimated value[2]		
		λ'	λ''	μ'	ν'		λ	μ	ν
—	—	—	—	—	—	(20.6)	−0.93	—	—
(3.0) & (4.0)	Constant E_{ij}	−0.92	−1.01	−0.04	—				
(3.0b) & (4.0b)[3]	Variables at—					(20.5)	− .96	0.07	-
	1932–34 average	− .70	− .93	.05	—				
	Mean	− .83	−1.30	− .12	—				
	1949–51 average	−1.24	−1.44	− .13	—				
(3.1a)'& (4.1a)[3]	Constant E_{ij}	− .78	−1.09	− .30	0.04				
(3.1) & (4.1)	Variables at—					[4]	− .95	.04	.01
	1932–34 average	− .71	− .93	− .46	.06				
	Mean	− .84	−1.30	− .69	.08				
	1949–51 average	−1.23	−1.44	− .57	.15				

[1] Computed from estimates of elasticities (E_{ij}) from specified demand equations where $\lambda' = E_{bb} - E_{pb}$; $\lambda'' = E_{pp} - E_{bp}$; $\mu' = E_{by} - E_{py}$; and $\nu' = E_{bt} - E_{pt}$.

[2] Computed from estimates of coefficients from specified price-ratio consumption-ratio functions where $\lambda = 1/\beta$; $\mu = -\gamma/\beta$; and $\nu = -\pi/\beta$.

[3] Equation numbers refer to reduced-form equations in note 1 from which demand elasticities were derived.

[4] Coefficients derived from the following equations:

$$\log P_r = -0.101 - 1.050 \log Q_r + 0.037 \log Y + 0.013 \log T$$
$$(.105) \qquad (.036) \qquad (.023)$$
$$R^2 = 0.890 \quad s = 0.03$$

in this respect. Once these equations have been fitted, an estimate of E_s, if desired, can be obtained directly from the direct or cross elasticities by making use of the relationships (15.0), (a) or (b), providing a = b. Since the purpose of this paper is to illustrate results from different approaches to measurement of substitution, we present empirical estimates from quantity-ratio price-ratio data.

As indicated earlier, income elasticities for beef and pork are nearly identical in equations (3.0) and (4.0), and other commodities are believed to have little effect on either of these items; so that the conditions required for the use of (5.0) to estimate E_s are met approximately. A differential income effect appears in the nonlogarithmic equation and becomes substantial if time is included as a variable. Table 2 shows the results of estimating E_s or λ from each of the two sets of direct and cross elasticities given by each pair of demand functions, or directly by

making use of comparable consumption and price ratios. These estimates are referred to in the table respectively as λ', λ'', and λ. The inequality between λ' and λ'' increases in the nonlogarithmic analyses and becomes substantial in the analyses including time as a variable. This would be expected because of the differential income effects referred to above. In the basic demand equations, all direct price elasticities are of correct sign and differ from zero by a statistically significant amount; estimates of cross elasticities, however, do not differ significantly from zero.

Empirical estimates of the elasticity of substitution may be obtained by fitting equations of form (5.0) or (13.0) by the least squares method, if prices are given, providing the conditions discussed above are met. However, for beef and pork, where quantities are assumed as given, the estimating equation takes the form

$$\log \frac{P_b}{P_p} = \alpha + \beta \left[\log \frac{Q_b}{Q_p} \right] + \gamma \log Y \tag{17.0}$$

where β is assumed constant whereas in (13.0), λ is assumed constant. The coefficients in equations (13.0) and (17.0) are related as follows:

$$K = \frac{-\alpha}{\beta}; \qquad \lambda = \frac{1}{\beta}; \qquad \mu = \frac{-\gamma}{\beta} \tag{18.0}$$

Just as the constant λ implied certain restrictions as to the relationship among price elasticity coefficients, the coefficient β also requires certain relationships among the price flexibility coefficients as is shown in the following relationships:

$$Q_r = \frac{Q_b}{Q_p} = \frac{AP_b{}^B P_p{}^C Y^D}{EP_b{}^F P_p{}^G Y^H} = \frac{A}{E} P_b{}^{(B-F)} P_p{}^{(C-G)} Y^{(D-H)} \tag{19.0}$$

$$= \frac{A}{E} \frac{P_b{}^{(B-F)}}{P_p{}^{(G-C)}} Y^{(D-H)} = KP_r{}^{\lambda} Y^{\mu}$$

$$P_r = \frac{P_b}{P_p} = \frac{aQ_b{}^b Q_p{}^e Y^d}{eQ_b{}^f Q_p{}^g Y^h} = \frac{a}{e} Q_b{}^{(b-f)} Q_p{}^{(e-g)} Y^{(d-h)}$$

$$= \frac{a}{e} \frac{Q_b{}^{(b-f)}}{Q_p{}^{(g-e)}} Y^{(d-h)} = \alpha Q_r{}^{\beta} Y^{\gamma} \tag{20.0}$$

By making use of the identities implied by equations (8.0) through (16.0), relation (19.0) transforms the demand equations for beef and pork algebraically (from left to right) into a substitution function equivalent to (13.0). It is functionally consistent with a constant E_s, providing $(B - F) = (G - C) = \lambda$, the condition specified in relation (16.0). In similar fashion,

relation (20.0) develops a substitution function equivalent to (17.0) from price-estimating equations for beef and pork.[13] This relation is consistent with a constant β if the relationships among the so-called price flexibility coefficients are as follows:

$$(b - f) = (g - c) = \beta = \frac{1}{\lambda} \tag{21.0}$$

From (20.0) and (21.0), it follows that, for beef and pork, whose quantities are predetermined in any given production period, the assumptions relating to a constant E_s and differential effect from income and the ith commodity can be tested directly from the price-estimating equations. The statistical equivalent, in logarithmic form, of relation (20.0) is as follows:

$$\log P_b = -2.056 - 1.136 \log Q_b + 0.026 \log Q_p + 1.834 \log Y \tag{20.1}$$
$$\qquad\qquad (.231) \qquad\quad (.202) \qquad\quad (.232)$$
$$R^2 = 0.94 \qquad s = 0.04$$

$$\log P_p = -1.870 - 0.039 \log Q_b - 0.974 \log Q_p + 1.709 \log Y \tag{20.2}$$
$$\qquad\qquad (.252) \qquad\quad (.221) \qquad\quad (.252)$$
$$R^2 = 0.89 \qquad S = 0.04$$

$$\log P_r = -0.186 - 1.097 \log Q_b + 1.000 \log Q_p + 0.125 \log Y \tag{20.3}$$

$$\log P_r = -0.189 - 1.096 \log Q_b + 1.000 \log Q_p + 0.124 \log Y \tag{20.4}$$
$$\qquad\qquad (.170) \qquad\quad (.149) \qquad\quad (.170)$$
$$R^2 = 0.891 \qquad S = 0.03$$

$$\text{og } P_r = -0.177 - 1.041 \log Q_r + 0.068 \log Y \tag{20.5}$$
$$\qquad\qquad (.102) \qquad\quad (.066)$$
$$R^2 = 0\ 887 \qquad S = 0.03$$

$$\log P_r = 0.015 - 1.075 \log Q_r \tag{20.6}$$
$$\qquad\qquad (.097)$$
$$R^2 = 0.880 \qquad S = 0.03$$

The price-estimating equations for beef and pork are given in (20.1) and (20.2).[14] Equations (20.3) to (20.6) present different ways of estimating the price ratio. Equation (20.3) is derived algebraically from (20.1 and (20.2), whereas (20.4), its equivalent, is fitted statistically. Since the results from these two equations will be identical except for rounding

[13] These are, in fact, the reduced-form equations fitted by least squares in the reduced-form method (see note 1).

[14] The structural coefficients given in equations (3.0) and (4.0) were derived from (20.1) and (20.2) by the reduced-form method (see note 1).

errors, coefficients from either can serve to test relation (21.0). For example, in (20.4), (b−f) = −1.096 and (g−c) = −1.000, indicating that (b−f) approximately equals (g−c). The estimate of β from (20.5) of −1.041 is approximately the average of (b−f) and (g−c). Because of the relatively small differential effect of income on the beef-pork price ratio, the estimate from the simple relation (20.6) is not significantly different from that of (20.5).

From (18.0), the estimates of the coefficients in equations (20.5) and (20.6) were used algebraically to compute estimates of elasticities of substitution and differential effects of income (λ and μ respectively in Table 2). It is noted that the differential income effect (μ) estimated from (20.5) is positive, whereas μ′ estimated from the demand equations is negative. This result is possible in a situation where conditions in (6.0) and (21.0) are not satisfied. That is, if β is not a constant, it follows that

$$K \neq \frac{-\alpha}{\beta} \text{ and } \mu \neq \frac{-\alpha}{\beta}$$

in relation (18.0).

In summary, we have developed conditions that are necessary for an estimate of E_s from price ratio, consumption ratio and income data, to equal the true E_s. For the particular data used in this study, the restrictive conditions seemed to be approximately satisfied. In general, this will not be the case, since there may be a more complex demand structure than implied by this equation and the elasticity of substitution may not be constant. Furthermore, if only the price-ratio consumption-ratio analysis is fitted, we have shown that it is impossible to tell whether the goods are complements, independent, or substitutes. We also have shown that a given value of E_s may be associated with different demand interrelationships, since the measure is a complex of direct price elasticities, cross price elasticities and income elasticities. Our conclusion, therefore, is that the statistical estimation of E_s is of dubious value, and its estimation by the price-ratio consumption-ratio method, with no other check as to the nature of the demand interrelationship, is meaningless.

A Partial Indifference Surface[15]

Most of the statistical estimation of demand interrelationships has been based either upon demand elasticities or upon the relation of consumption ratios to price ratios. Waugh, in a recent article, presented a

[15] This section is an application to Canadian data of the method formulated by Frederick V. Waugh, *op. cit.*, for deriving a partial indifference surface.

partial indifference surface for the consumption of beef and pork in the United States.[16]

The partial indifference function used by Waugh is

$$Z = A\frac{[1 - (c - g)]}{[1 + (b - f)]}Q_b^{1+(b-f)} + Q_p^{1-(c-g)} \qquad (22.0)$$

where Z represents the elevation of a surface. For each value of Z, there exists a contour line (partial indifference curve) that represents substitution possibilities of beef and pork for which consumers are indifferent. In contrast to a production function, in which Z can be taken as a direct measure of output, the Z in (22.0) is not intended to give a direct measure of the level of utility. Instead, Z may be considered a monotonic function of utility from which it is possible to obtain contours (indifference curves) for each value of Z.

If Z is a single valued, monotonic function of utility, say $Z = \Phi(U)$, the marginal rate of substitution (or the slope of a contour line) is

$$\frac{\partial Z}{\partial Q_b} \Big/ \frac{\partial Z}{\partial Q_p} = \frac{\partial[\phi(U)]}{\partial Q_b} \Big/ \frac{\partial[\phi(U)]}{\partial Q_p}$$

where $\partial[\Phi(U)]/\partial Q_b$ equals the marginal utility of beef and $\partial[\Phi(U)]/\partial Q_p$ equals the marginal utility of pork. In competitive equilibrium, the marginal rate of substitution between beef and pork must equal the ratio of their prices or

$$\frac{\partial Z}{\partial Q_b} \Big/ \frac{\partial Z}{\partial Q_p} = P_r.$$

But the slope of the contours of Z in (22.0) at any point is

$$\frac{\partial Z/Q_b}{\partial Z/Q_p} = AQ_b^{(b-f)}Q_p^{(c-g)} \qquad (23.0)$$

which also equals the price ratio, i.e.

$$P_r = AQ_b^{(b-f)}Q_p^{(c-g)} \qquad (24.0)$$

In logarithmic form, this equals

$$\log P_r = \log A + (b - f)\log Q_b + (c - g)\log Q_p \qquad (24.1)$$

Estimates for the coefficients in (22.0) can be obtained algebraically from the coefficients in (24.0). Coefficients in (24.1), in turn, can be derived from an equation, fitted by least squares, of the form

$$\log P_r = \log {}^a/_o + (b - f)\log Q_b + (c - g)\log Q_p + (d - h)\log Y \qquad (25.0)$$

which includes income as a variable. For any given level of income, if we substitute in (25.0) the value of Y, we obtain an equation of form (24.0).

[16] F. V. Waugh, *op. cit.*

In short, equation (24.0) gives us an *adjusted* price ratio estimating equation which corresponds to a specific level of income.

Waugh's analysis implies that for each level of money income, there is a definite indifference surface for beef and pork. This means that the constant (A) in equation (24.0) may vary with income. This also is true for the constant in equation (22.0). In a sense, equation (22.0) is that of a three-dimensional surface and may be thought of as a cross section of a four-dimensional surface, holding income constant at some specified level.

Let us now apply Waugh's formulation of the partial indifference function to the Canadian data. Equations (20.3) and (20.4), fitted above (see p. 725), are statistical equivalents of equation (25.0). If income per capita is held at \$648.53, the average for the years included in the analysis, we can derive values for equation (24.0) using equation (20.4). From this equation, the values for equation (22.0) become as follows:

$$Z = 0.0030\ Q_b^{-0.0957} + Q_p^{-0.0002} \qquad (22.1)$$

Logically, we would have expected *positive* exponents in (22.1) which would indicate that consumers would be "better off" with more beef and pork, holding real income constant. For nuisance goods we would have expected negative exponents. It should be noted that the exponential coefficients are based on price flexibility coefficients for beef and pork. For example, the exponent -0.0957 equals $[1 + (b - f)]$ where $(b - f)$ is the difference between the direct price flexibility for beef and the cross flexibility of the price of pork with respect to beef consumption. The exponents in equation (22.0) are both positive only when the value of $(b - f)$ is between zero and minus one, and the value $(c - g)$ is between zero and plus one. In terms of demand elasticities, a *negative* exponent appears whenever the sum of the direct price elasticity of beef minus the cross elasticity of pork with respect to the price of beef is between zero and minus one. Many related agricultural commodities may fall within this range.

The function selected in this case was one of several possible monotonic functions. Waugh was concerned only with obtaining a set of contours (a set of indifference curves) consistent with consumer theory and with the formulation of demand interrelationships assumed to exist. As he states, "we are not assuming here that Z is a measure of utility. Any monotonic function of Z will give the same set of contour lines. But any function of (Q_b, Q_p) that is not a monotonic function of Z will give different contour lines. These will not be consistent with equations (1) and (3) [or in this paper, equations (25.0 and (24.0)]. Therefore, if (1) and (3) are taken as adequate statistical measures of demand interrelation-

ships of the beef-pork price ratio, we must conclude that the contour lines in Figure 2 [comparable to Figure 2 in this paper] describe the only indifference surface that is consistent with our statistical results and with the assumption of rational consumer choice."[17]

Let us assume that, for our range of data, the partial indifference surface for beef and pork should be a monotonic increasing function. For the Canadian data, we found that the value of $(b - f)$ was approximately equal to $(g - c)$, implying a constant elasticity of substitution [(β), see relation (20.4)]. Assuming that $(b - f) = (g - c) = \beta$, a monotonic increasing function which will still provide the same set of contour lines is

$$Z = [AQ_b^{(1+\beta)} + Q_p^{(1+\beta)}]^{\frac{1}{1-\beta}} \tag{26.0}$$

where the slope of any contour equals the price ratio in competitive equilibrium, or

$$\frac{\partial Z/\partial Q_b}{\partial Z/\partial Q_p} = AQ_b^{\beta}Q_p^{-\beta} = AQ_r^{\beta} = P_r \tag{27.0}$$

The partial indifference function (26.0) is a monotonic function increasing at a decreasing rate for all values of β from (0) to $(-\infty)$, and increasing at a constant rate for $\beta = 0$; and, when $\beta = -\infty$, the function describes a horizontal surface. Thus the function defines a family of surfaces that vary in steepness depending on the value of β for a given level of income. Hence, for any combination of beef and pork consumption, the steepness of the indifference surface is functionally related to the direct price elasticities and the cross price elasticities, which, in turn, reflect marginal utilities of the two goods. But it should be emphasized again that Z is not a measure of the level of utility.

The empirical equivalent of (27.0) is

$$P_r = 1.033Q_r^{-1.041} \tag{27.1}$$

which is equivalent to

$$\text{est. log } P_r' = 0.014 - 1.041 \log Q_r \tag{28.0}$$

which, in turn, was obtained by letting per capita real income equal \$648.53 in equation (20.5). From this it follows that the partial indifference surface [i.e., the empirical equivalent of (26.0)] is

$$Z = [1.033Q_b^{-0.041} + Q_p^{-0.041}]^{-11.9} \tag{26.1}$$

Figure 2 shows, for each year, the contour line (partial curve) associated with the quantities of beef and pork consumed had per capita real

[17] F. V. Waugh, *op. cit.*, p. 111.

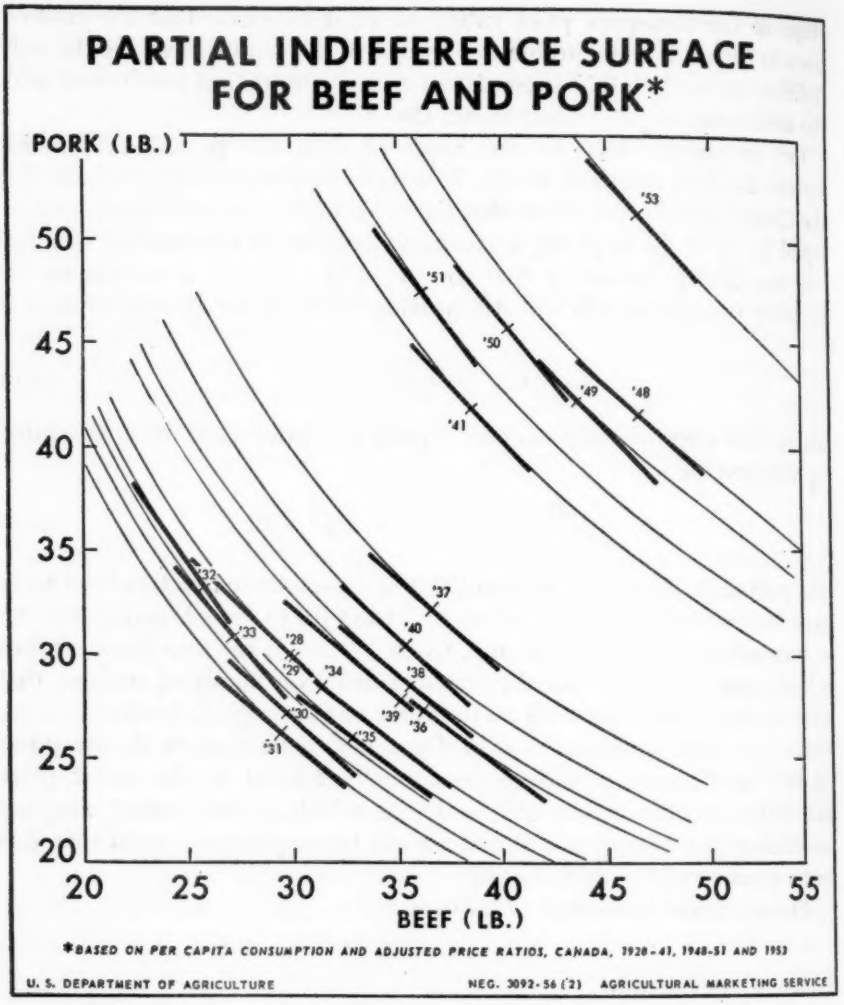

FIG. 2. ESTIMATED PARTIAL INDIFFERENCE SURFACE FOR BEEF AND PORK CONSUMPTION PER PERSON, CANADA, 1928-41, 1948-51 AND 1953.

income been \$648.53 in that year. The contour line for a specific year (t) can be expressed as

$$Q_p = [Z_t^{-0.084} - 1.033Q_b^{-0.041}]^{-24.4} \qquad (29.0)$$

where Z_t is the value of Z for year t computed from (26.1).

Figure 2 also shows the *adjusted* price ratio (P_r') associated with the quantities of beef and pork consumed during that year had per capita real income remained constant at \$648.53. These adjusted ratios were

TABLE 3. BEEF-PORK PRICE RATIOS: ACTUAL AND ESTIMATED FROM SPECIFIED STATISTICAL ANALYSES, CANADA, 1928–53

Year	Not adjusted		Adjusted[2]	
	Actual	Estimated[1]	Actual	Estimated[3]
1928	1.024	1.030	1.026	1.033
1929	.978	1.021	.982	1.026
1930	.955	.929	.964	.938
1931	.873	.918	.888	.933
1932	1.476	1.309	1.510	1.340
1933	1.159	1.143	1.189	1.172
1934	.799	.908	.814	.925
1935	.798	.796	.811	.809
1936	.753	.757	.764	.767
1937	.893	.889	.902	.897
1938	.831	.813	.840	.820
1939	.846	.805	.851	.811
1940	.977	.875	.977	.875
1941	1.067	1.138	1.062	1.132
1942	.946	1.084	.931	1.067
1943	1.000	1.114	.982	1.094
1944	1.052	1.493	1.027	1.459
1945	1.052	1.096	1.025	1.069
1946	1.047	.618	1.021	.603
1947	.979	.665	.958	.650
1948	.939	.938	.916	.916
1949	1.107	1.021	1.084	1.000
1950	1.292	1.211	1.262	1.183
1951	1.337	1.403	1.303	1.368
1952	1.581	1.361	1.542	1.327
1953	1.108	1.169	1.078	1.138

[1] Computed from equation (20.5): $\log P_r = -0.177 - 1.041 \log Q_r + 0.068 \log Y$.

[2] Price ratio associated with the quantities of beef and pork consumed during that year had per capita real income remained constant at $648.53. The price ratio in any year is adjusted for the differential income effect [(0.068) from equation (20.5)] and is computed from relation (30.0): $\log P_r' = \log P_r - 0.068 \log Y + 0.191$.

[3] Computed from equation (28.0): $\log P_r' = 0.014 - 1.041 \log Q_r$.

computed for each year from the relation:

$$\begin{aligned} \log P_r' &= P_r - 0.068 (\log Y - \log 648.53) \\ &= \log P_r - 0.068 \log Y + 0.191 \end{aligned} \qquad (30.0)$$

where the price ratio in any year is adjusted for the differential income effect [(0.068) from equation (20.5)].

If conditions of competitive equilibrium are met and if the contour function represents the true substitution possibilities between beef and pork, we would expect the *adjusted* price ratio to be tangent to the contour line for the particular quantities of beef and pork consumed for that year.[18] Inspection of Figure 2 tends to substantiate this formulation. The

[18] The shape of the indifference curve depends on the degree of substitution between a pair of commodities and becomes a straight line for goods that are perfect

closeness of fit for any year can be seen also by comparing the adjusted price ratio obtained from (30.0) with the estimated adjusted price ratio (est P_r') obtained from equation (28.0). These comparisons are shown in the last two columns of Table 3. Thus, the accuracy of the assumption as to the shape of the contour lines is tested by comparing the actual shape of the partial indifference curve (i.e., est. P_r') with the actual price ratio adjusted for differential income effect.

Summary and Conclusions

Three measures of demand interrelationships have been discussed: first, elasticities derived from statistical demand equations; second, the elasticity of substitution derived from price ratios and consumption ratios; and third, partial indifference surfaces derived from demand coefficients and an assumed monotonic function of utility. How are these measures related? The demand curve can be derived, theoretically, from an indifference surface. For one commodity, we can consider a diagram with its quantity plotted on the X axis and quantity of "all other goods" (money) plotted on the Y axis. Changes in the relative price of X to all other goods generates a demand curve. Also, the elasticity of substitution is a measure which, in the basic sense, limits movement to an indifference curve, and indicates the "ease of substitution" between two commodities. Thus, all three measures attempt to specify demand relationships, but determination of the demand elasticities are basic to the statistical estimation of each of them.

From a statistical viewpoint, the demand equation approach contributes the most information since the elasticity of substitution and the partial indifference surface as developed by Waugh are based upon the interrelationships of the individual demand coefficients. The degree of competition can be observed directly by comparison of cross elasticities. In addition, the numerical values of the demand elasticities with respect to price and income have the well-known interpretation as to the effects on expenditures.

Two conclusions with respect to the elasticity of substitution can be drawn. First, an empirical estimate of the true E_s can be obtained by

substitutes. The shape of the empirical indifference curve presented here depends directly on a particular combination of elasticities of demand for beef and pork. As was shown in the discussion of the elasticity of substitution, results obtained from a method of estimation that is based on some combination of direct price elasticities and cross price elasticities do not provide sufficient information (1) to conclude that a pair of commodities are substitutes and (2) to determine the precise degree of substitution when they are known to be substitutes. Thus, the empirical indifference curve presented here also is subject to these limitations. We know that beef and pork are substitutes. The relative flatness of the curve does not tell us the precise degree of substitution between these commodities.

relating price ratios and consumption ratios *only* under very restrictive conditions, as developed theoretically by Morrissett and illustrated in this paper. When price ratios and quantity ratios are related, a poor fit may be indicated for direct substitutes and a good fit for independent commodities. Moreover, the regression coefficient will not necessarily tell us whether goods are competing, independent, or complementary, let alone the "ease of substitution." Second, it is demonstrated that even knowing that two goods are competing, the numerical value of E_s $[0 - \infty]$ tells us little about the "ease of substitution" or the degree of competitiveness between the goods, its designed purpose. This follows since the measure E_s is a combination of direct price elasticities and cross price elasticities and income elasticities.

Waugh's method of obtaining a partial indifference surface broadens the scope for estimating statistical demand interrelationships, obtains contour lines (indifference curves) consistent with consumer theory, but does not attempt to measure utility.

In summary, the research analyst will, in general, wish to obtain direct elasticities and cross elasticities by the regression approach. If he is dealing with equations that relate to individual consumers, so that prices can be assumed to be given, he can use the usual single-equation regression approach. If he is dealing with market aggregates for which consumption can be considered as predetermined, he can use the reduced-form approach. If consumption cannot be considered as predetermined, he probably will need to use the limited information approach. The approach suggested by Waugh for obtaining a partial indifference surface will undoubtedly stimulate research in an area of demand analysis hitherto reserved for theoretical discussion.

NOTE 1. RELATIONSHIP BETWEEN PRICE-ESTIMATING EQUATIONS AND STRUCTURAL DEMAND EQUATIONS

The reduced-form method of estimating demand coefficients is used in this analysis of demand for beef and pork, where it is assumed that quantities consumed and consumer income are given. It is possible to obtain coefficients for the structural demand equations directly from the reduced-form (price-estimating) equations by algebraic transformation.

Reduced-form equations:

$$P_b = \alpha_b + \beta_{11}Q_b + \beta_{12}Q_p + \beta_{13}Y + \beta_{14}T$$
$$P_p = \alpha_p + \beta_{21}Q_b + \beta_{22}Q_p + \beta_{23}Y + \beta_{24}T$$

Demand Equations:

$$Q_b = a_b + b_{11}P_b + b_{12}P_p + b_{13}Y + b_{14}T$$
$$Q_p = a_p + b_{21}P_b + b_{22}P_p + b_{23}Y + b_{24}T$$

Algebraic relation of coefficients:

$$b_{11} = \frac{\beta_{22}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}} \qquad b_{22} = \frac{\beta_{11}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}}$$

$$b_{12} = \frac{-\beta_{12}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}} \qquad b_{21} = \frac{-\beta_{21}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}}$$

$$b_{13} = \frac{\beta_{12}\beta_{23} - \beta_{13}\beta_{22}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}} \qquad b_{23} = \frac{\beta_{21}\beta_{13} - \beta_{23}\beta_{11}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}}$$

$$b_{14} = \frac{\beta_{12}\beta_{24} - \beta_{14}\beta_{22}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}} \qquad b_{24} = \frac{\beta_{21}\beta_{14} - \beta_{24}\beta_{11}}{\beta_{22}\beta_{11} - \beta_{12}\beta_{21}}$$

If the above equations are run with all variables expressed in logarithms, the reduced-form equations immediately give the "price flexibilities." It is important to note that the reciprocal of the "price flexibility" for beef (β_{11}) equals the price elasticity (direct) for beef (b_{11}) *only* if β_{12} and β_{21} are zero. Thus, empirical studies that have been published with the elasticity of demand derived by taking the reciprocal of the price flexibility coefficient have made the implicit assumption that other goods do not affect measurably the consumption of the good. The algebraic relation of the coefficients indicates clearly that the reciprocal of the cross price flexibility does not give the cross elasticity of demand. The same holds for the income coefficient.

The reduced-form (price-estimating) equations used to obtain coefficients in the structural equations were estimated by the least squares method and are presented below:

Equations for which logarithmic relationships were assumed:

$$\log P_b = -2.056 - 1.136 \log Q_b + 0.026 \log Q_p + 1.834 \log Y \qquad (3.0a)$$
$$\qquad\qquad (.231) \qquad\quad (.202) \qquad\quad (.232)$$
$$R^2 = 0.94 \qquad S = 0.040$$

$$\log P_p = -1.870 - 0.039 \log Q_b - 0.974 \log Q_p + 1.709 \log Y \qquad (4.0a)$$
$$\qquad\qquad (.252) \qquad\quad (.221) \qquad\quad (.252)$$
$$R^2 = 0.89 \qquad S = 0.044$$

$$\log P_b = -1.887 - 1.375 \log Q_b - 0.103 \log Q_p + 1.959 \log Y + 0.048 \log T \qquad (3.0b$$
$$\qquad\qquad (.330) \qquad\quad (.239) \qquad\quad (.262) \qquad\quad (.047)$$
$$R^2 = 0.94 \qquad S = 0.040$$

$$\log P_p = -1.852 - 0.065 \log Q_b - 0.989 \log Q_p + 1.723 \log Y + 0.005 \log T \qquad (4.0b)$$
$$\qquad\qquad (.373) \qquad\quad (.270) \qquad\quad (.296) \qquad\quad (.053)$$
$$R^2 = 0.89 \qquad S = 0.044$$

Equations for which linear relationships were assumed:

$$P_b = 8.77 - 0.945\,Q_b - 0.062\,Q_p + 0.079\,Y \qquad (3.1a)$$
$$\qquad\quad (.215) \qquad (.212) \qquad (.012)$$
$$R^2 = 0.92 \qquad S = 0.030$$

$$P_p = 9.57 - 0.152\,Q_b - 0.644\,Q_p + 0.065\,Y \qquad (4.1a)$$
$$\qquad\quad (.164) \qquad (.162) \qquad (.010)$$
$$R^2 = 0.89 \qquad S = 0.023$$

$$P_b = 20.69 - 1.211\,Q_b - 0.253\,Q_p + 0.077\,Y + 0.420\,T \qquad (3.1b)$$
$$\qquad\quad (.257) \qquad (.230) \qquad (.012) \qquad (.250)$$
$$R^2 = 0.93 \qquad S = 0.028$$

$$P_p = 11.54 - 0.196\,Q_b - 0.676\,Q_p + 0.064\,Y + 0.069\,T \qquad (4.1b)$$
$$\qquad\quad (.215) \qquad (.192) \qquad (.010) \qquad (.208)$$
$$R^2 = 0.89 \qquad S = 0.023$$

The figures in brackets are the standard errors of the regression coefficients. These equations have the same number as their corresponding structural demand equations, but subscripts were added to indicate the exclusion (a) or inclusion (b) of the time variable in the analysis.

FUNCTIONAL RELATIONSHIPS FOR IRRIGATED CORN RESPONSE TO NITROGEN

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Introduction

ECONOMIC and agronomic analyses of fertilizer experiments are based on the premise that a functional relationship exists between the yield of plants and fertility levels. This relationship is not known precisely and theories of yield response are not well enough developed to provide it on an *a priori* basis. Researchers hope that some form of mathematical function may be found that can be used to generalize the response of plants to application of given amounts of fertilizer. In the search for this generalization, a variety of mathematical functions, any one of whose characteristics reflect known basic postulates of yield response, may be fitted to experimental data.

A generally applicable function of yield response cannot be established from a single set of experimental data but a theory that has been tested by repeated application to experimental data eventually should permit specification of the form of the fertilizer response function. If this is done, answers to many questions about plant response to nutrients may be found. Also, estimates of the most profitable rate of fertilizer application may be made without the need for expensive experiments in so many different places and situations.

Past experimental evidence specifies that a functional relationship between the yield of a crop and nutrient factor of production, in general, should conform with the principle of diminishing increments or diminishing marginal product. This includes experiments that reflect a phase of increasing increments at low levels of nutrient application. Under certain conditions, such as a limited quantity of available moisture or similar situations, the experimental data might show that the yield had reached a maximum and, under additional applications of the nutrient, result in negative increments in yield. This negative increment segment may affect materially the estimates of the functional relationship in that segment that has an economic significance. The purpose of this paper is to estimate the response of corn to nitrogen by different suggested mathematical functions, using experimental data provided for this purpose.

Data used in this paper came from experiments with nitrogen on irrigated corn in Oregon, Washington, and Nebraska. These experiments were conducted by soil scientists of the Soil and Water Conservation Research Branch, Agricultural Research Service, and the State experiment

stations. They were designed in cooperation with J. L. Paschal, D. B. Ibach and other interested agricultural economists so that thorough analyses of response functions could be investigated. They differed from most fertilizer response experiments conducted up to that time in that a larger number of rates of application of nitrogen were used and the highest rates were well above usual applications.[1]

In the experimental areas, nitrogen is the only nutrient to which corn consistently responds. Nitrogen was applied at 12 different rates. They were 0, 40, 80, 100, 120, 140, 160, 180, 200, 240, 280, and 320 pounds per acre in the Nebraska and Oregon experiments and 0, 40, 80, 120, 160, 200, 240, 280, 320, 360, 440, and 520 pounds per acre in the Washington experiment. The sources of nitrogen were ammonium nitrate in Washington and Nebraska and ammonium sulfate in Oregon. The experimental design was a randomized block design with three, four, and five replicates, respectively, in the Washington, Oregon, and Nebraska experiments.

The objective of the analysis reported here is to test the applicability of different mathematical functions to represent the data and to determine whether or not reliable functions could be estimated from experiments with fewer rates of application of the nutrients. Different mathematical functions are fitted to the full data and, to investigate ways to reduce the size of experiments, comparisons are made between estimates that use parts of the data (subsamples of rates) and estimates that use all the data.

Comparisons of Different Functional Relationships

Several mathematical functions have been used to describe plant response to fertilizer. Spillman[2] derived the form of the exponential function, $Y = M - AR^x$, from experimental data. Here the assumption is that the ratio between successive yield increases for successive additional fertilizer increments is constant and that the yield approaches a maximum. This function does not reach a specific maximum and then reflect negative increments of yield, even though experimental data signifies such a condition.

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[1] For more details on these experiments, see J. L. Paschal and B. L. French, *A Method of Economic Analysis Applied to Nitrogen Fertilizer Rate Experiments on Irrigated Corn*, USDA Tech. Bul. 1141, 1956, Tables 40, 41, and 42. Experimental data on which this paper is based were supplied by the Soil and Water Conservation Research Branch, Agricultural Research Service, U. S. Dept. of Agr., in cooperation with the State Agricultural Experiment Stations of Oregon, Washington, and Nebraska.

[2] W. J. Spillman, *Use of the Exponential Yield Curve in Fertilizer Experiments*, USDA Tech. Bul. 348, and W. J. Spillman and Emil Lang. *The Law of Diminishing Returns*, World Book Company, Yonkers-on-Hudson, New York, 1924.

Heady and Pesek, Johnson,[3] and others have used the quadratic equation, $Y = a + b_1 X + b_2X_2$. This function will ordinarily reach a maximum yield and then reflect negative increments. Another function that has been suggested by Heady is a transformation of the general quadratic function where the independent variable, X, is represented by $\sqrt{X}$, $Y = a+b_1 \sqrt{X}+b_2X$. This function is similar to the quadratic but the maximum yield is reached at much higher values of fertilizer input.

Another function, the Cobb-Douglas power function that is linear in the logarithms of the dependent and independent variables, $Y = aX^b$, is useful for many economic investigations. This function reflects the assumption that a constant elasticity of response exists over the entire range of the data. It will not reflect negative increments of yield.

Several scientists have proposed the hypothesis that the function should reflect increasing yields at an increasing rate at the lower levels of the input factor. The Gompertz curve, $Y = e^{(M-AR^x)}$, a modification of the exponential function, satisfies this requirement.

Production Function Estimates

Each of the above five functions was fitted to the means of the treatments of each of the three experiments by the usual least-squares procedures. The estimated curves for the exponential, quadratic-square-root, and quadratic functions are illustrated in Figure 1. Inasmuch as the estimated constants of each function are not directly comparable, the basis for comparisons as to the "best" fit are the sums of squares of deviations about the regression line and by the square root of the ratio of the sums of squares due to regression to the sums of squares of the total for treatments. These measures are shown in Table 1.

In 2 of the 3 experiments, the Gompertz function has a lower sum of squares of the deviations and a higher coefficient of multiple correlation, with the exponential function having the second lowest. In the Prosser experiment the exponential function was the "best" fitting function in terms of the sums of squares of the deviations from the regression line. The least-squares estimates for the Cobb-Douglas and Gompertz functions in terms of the logarithms may not be least-squares estimates in terms of actual experimental data. In all experiments, the Cobb-Douglas function had the largest sum of squares of deviations about the fitted regression line.

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[3] Earl O. Heady, and John Pesek, "A Fertilizer Production Surface with Specifications of Economic Optima for Corn Grown on Calcareous Ida Silt Loam," *Journal of Farm Economics*, Volume 36, No. 3, August 1944. Paul Johnson, "Alternative Functions for Analyzing a Fertilizer-Yield-Relationship," *Journal of Farm Economics*, Volume 35, No. 4, November 1953.

The Gompertz curve shows little advantage for all three sets of experimental data over other functions in line with other variations not accounted for by the functional relationship. The computations are the same as for the exponential function, except that the least squares of the natural logarithms are obtained. The Gompertz function is complex and

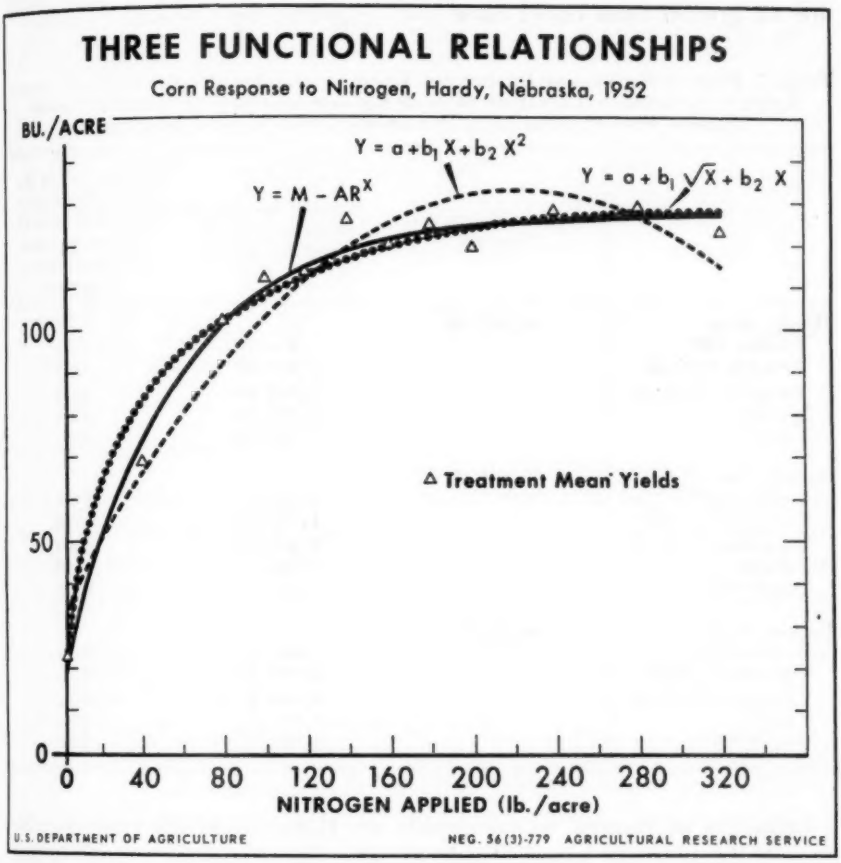

FIG. 1

estimates of the most profitable rate of application and the maximum yield are difficult to obtain. The Cobb-Douglas function does not appear to follow the principle of diminishing increments. The estimated regressions make it appear to be unsatisfactory for use in estimating physical response relationships.

The total variablility in the experiments was considerable although, as might be expected, the treatment variability in each experiment ac-

counted for a very large portion of the total (tables 1 and 2). In all three experiments, more than 90 percent of the treatment variability is explained by the regression of yield on fertilizer levels, except for the regression estimate of the Cobb-Douglas function in the Ontario experiment. F-tests of significance measured by the ratio of the mean square due to regression to the mean square of the deviations about regression are all greater than could have been expected by chance.

TABLE 1. SUMS OF SQUARES OF DEVIATIONS ABOUT REGRESSION AND SQUARE ROOT OF THE RATIO OF REGRESSION EXPLAINED SUMS OF SQUARES TO TOTAL TREATMENT SUMS OF SQUARES, FIVE MATHEMATICAL FUNCTIONS, THREE 12-RATE EXPERIMENTS

	Treatment sums of squares	Sums of squares of deviations about regression line	Square root of the ratio of regression explained sums of squares to total treatment sums of squares
Hardy, Nebr.	53,897.00		
$Y=M-AR^X$		808.70	0.9925
$Y=a+b_1X+b_2X^2$		3,715.50	.9648
$Y=a+b_1\sqrt{X}+b_2X$		1,925.00	.9819
$Y=aX^b$		4,424.90	.9581
$Y=e^{(M-AR^X)}$		525.35	.9951
Ontario, Ore.	30,631.94		
$Y=M-AR^X$		1,012.16	.9834
$Y=a+b_1X+b_2X^2$		1,385.32	.9772
$Y=a+b_1\sqrt{X}+b_2X$		2,403.60	.9600
$Y=aX^b$		5,090.32	.9133
$Y=e^{(M-AR^X)}$		761.12	.9875
Prosser, Wash.	64,588.4		
$Y=M-AR^X$		921.60	.9928
$Y=a+b_1X-b_2X^2$		3,776.10	.9703
$Y=a+b_1\sqrt{X}+b_2X$		2,086.17	.9837
$Y=aX^b$		5,247.24	.9585
$Y=e^{(M-AR^X)}$		2,161.29	.9880

Estimates of interest to economists are those on which recommendations to farmers are based (Table 3). The "most profitable rate" is that rate of fertilizer application at which the value of the additional increment of yield obtained will equal the value of the additional increment of fertilizer applied ($\Delta Y.P_Y = \Delta X.P_X$, where ΔY is the yield increment, P_Y the value per unit of product, ΔX the fertilizer increment, and P_X the cost of q pounds of fertilizer). Application of more or less fertilizer than the quantity so indicated would reduce income to the farmer.

For the exponential, quadratic, and quadratic-square-root functions, no outstanding differences appear among the estimates of the most profitable rates. Likewise, the estimated yields at these most profitable

TABLE 2. ANALYSIS OF VARIANCE OF THE THREE 12-RATE EXPERIMENTS CONDUCTED AT HARDY, NEBR., ONTARIO, ORE., AND PROSSER, WASH.

Source of variation	Degrees of freedom	Sums of squares	Mean square	F
Hardy, Nebr.				
Replicates	4	1,556.81	389.2	
Treatments	11	53,897.00	4,899.7	55.10*
Experimental error	44	3,846.28	87.4	
Total	59	59,300.09		
Ontario, Ore.				
Replicates	3	941.47	313.8	
Treatments	11	30,631.94	2,784.7	41.69*
Experimental error	33	2,204.29	66.8	
Total	47	33,777.70		
Prosser, Wash.				
Replicates	2	2,284.5	1,142.3	
Treatments	11	64,588.4	5,871.7	72.58*
Experimental error	22	1,779.8	80.9	
Total	35	68,652.7		

* Significant at a probability level of 0.01.

rates differ little. The highest estimate of the most profitable rate was found with the quadratic function in 2 of 3 functions, with the third slightly below the quadratic-square-root function. For the exponential and quadratic-square-root functions, the yield at the most profitable rate

TABLE 3. ESTIMATED MOST PROFITABLE RATES OF NITROGEN APPLICATION TO CORN, ESTIMATED YIELD AT THAT RATE, MAXIMUM YIELD, AND HIGHEST EXPERIMENTAL YIELD, THREE MATHEMATICAL FUNCTIONS, THREE 12-RATE EXPERIMENTS

	Most profitable rate of nitrogen application	Yield at MPR	Theoretical maximum yield	Highest experimental yield
	Pounds	*Bushels*	*Bushels*	*Bushels*
Hardy, Nebr.				152.3
$Y=M-AR^X$	164.0	121.6±1.22	127.8	
$Y=a+b_1X+b_2X^2$	196.7	131.7±3.55	133.2	
$Y=a+b_1\sqrt{X}+b_2X$	180.0	121.9±2.14	127.7	
Ontario, Oreg.				159.9
$Y=M-AR^X$	173.0	142.7±1.72	150.2	
$Y=a+b_1X+b_2X^2$	194.0	150.4±2.43	152.0	
$Y=a+b_1\sqrt{X}+b_2X$	182.0	141.9±2.67	150.6	
Prosser, Wash.				165.1
$Y=M-AR^X$	274.0	140.9±1.99	152.7	
$Y=a+b_1X+b_2X^2$	327.0	152.6±4.83	156.1	
$Y=a+b_1\sqrt{X}+b_2X$	336.0	143.9±3.13	163.2	

was three or more standard errors below the theoretical maximum yield.

The returns and costs estimated by the different functions are shown in Table 4 for each of the three experiments. The predicted net return due to nitrogen is the value of the increased yield above that yield estimated at the zero level of nitrogen applied. There is little difference among the net returns estimated from the respective functions for each experiment compared with variations that could occur in predicted yields when confidence limits are estimated for these yields. For the functions where the predicted yields at the most profitable rate are high, the predicted yield at the zero level of nitrogen application and the cost of the nitrogen applied are also higher.

TABLE 4. YIELDS, COSTS, AND RETURNS AT THE MOST PROFITABLE RATE OF NITROGEN APPLIED[1]

	Predicted yield at zero application of nitrogen	Total returns at the most profitable rate		Increase in returns due to nitrogen		Nitrogen applied at MPR	Cost of nitrogen	Net returns due to nitrogen
	Bushels	*Bushels*	*Dollars*	*Bushels*	*Dollars*	*Pounds*	*Dollars*	*Dollars*
Hardy, Neb.								
$Y=M-AR^X$	21.0	121.6	170.24	100.6	140.84	164.0	24.60	116.24
$Y=a+b_1X+b_2X^2$	34.1	131.7	184.38	97.6	136.64	196.7	29.51	107.14
$Y=a+b_1\sqrt{X}+b_2X$	18.6	121.9	170.66	103.3	144.62	180.0	27.00	117.62
Ontario, Ore.								
$Y=M-AR^X$	60.8	142.7	199.78	81.9	114.66	173.0	25.95	88.71
$Y=a+b_1X+b_2X^2$	67.7	150.4	210.56	82.7	115.78	194.0	29.10	86.68
$Y=a+b_1\sqrt{X}+b_2X$	58.7	141.9	198.66	83.2	116.48	182.0	27.30	89.04
Prosser, Wash.								
$Y=M-AR^X$	9.9	140.9	197.25	130.9	183.26	274.0	41.10	142.30
$Y=a+b_1X+b_2X^2$	28.3	152.6	213.64	124.3	174.02	327.0	49.05	124.97
$Y=a+b_1\sqrt{X}+b_2X$	5.2	143.9	201.46	138.7	194.18	336.0	50.40	143.78

[1] Corn priced at $1.40 per bushel in the field and nitrogen priced at 15 cents per pound applied to the corn.

Estimating Yield Response Functions With Fewer Rates of Fertilizer Application

The value of many of the fertilizer experiments conducted in the past has been questioned because the number of rates of application were insufficient to permit "accurate" estimation of the yield response functions and the related economic factors. Experiments like the three analyzed in this paper are ideal but it is difficult and expensive to conduct such experiments. Two particular problems are encountered: (1) the finding of a sufficient number of homogeneous plots and (2) the financial cost of the experiment. Is it possible to design an experiment that will involve functional relationships between yield and some controlled and quantifiable variable that can be easily handled in obtaining experimental plots within the limits of research funds available?

To investigate this question, small numbers of the rates were chosen

and the functions were fitted to these smaller series of data. The estimated functions and the corresponding measures of profitability were compared with the estimates made from all 12 rates in the same procedure as comparing a sample to the population from which they were drawn, although the samples used will soon be seen distinctly to be nonrandomly chosen. The five subgroups studied were: (1) the first 4 rates in each experiment; (2) the first 5 rates in each experiment; (3) the first 7 rates in the experiment; (4) 5 rates equally spaced over the entire range; and (5) 6 rates distributed over the range. In all groups, the first rate–zero pounds of nitrogen applied–was included. In (4) and (5), the

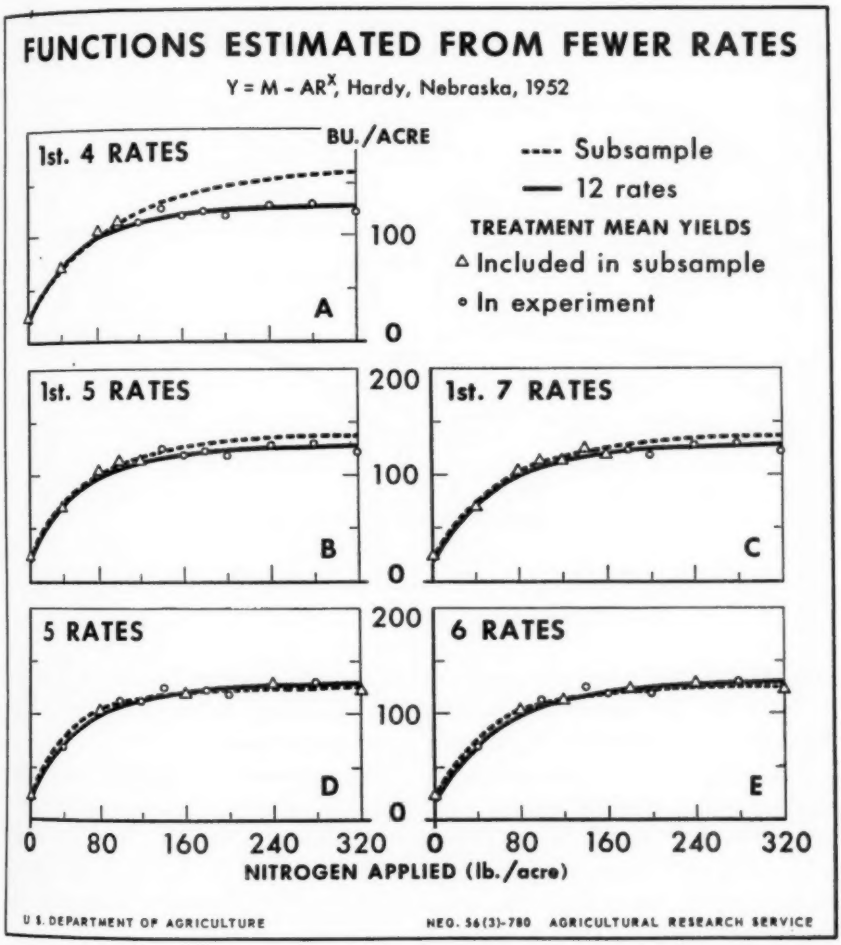

FIG. 2

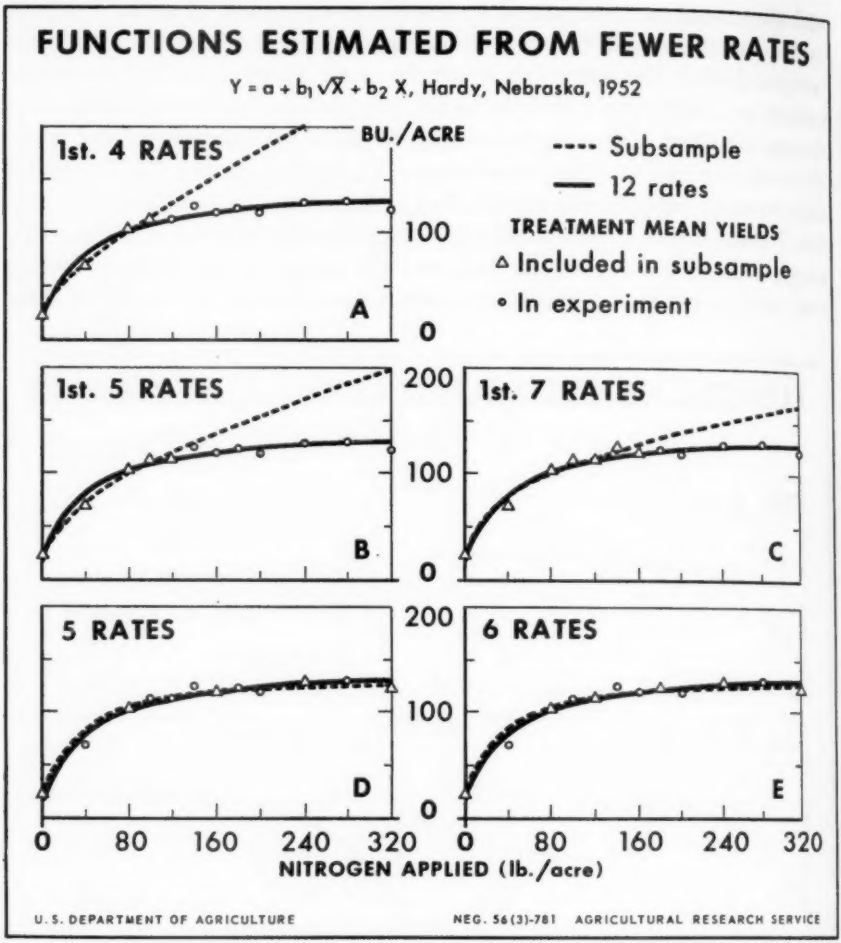

FIG. 3

highest rate included the twelfth rate, sixteen 20-pound units of nitrogen applied for the Hardy, Nebr. and Ontario, Oreg. experiments, and thirteen 40-pound units for the Prosser, Wash. experiment.

The respective estimated curves for the exponential and the quadratic-square-root functions for each subgroup of data are shown in figures 2 and 3 for the Hardy, Nebr., experiment. The estimates of the most profitable rate of nitrogen application, predicted yield at the most profitable rate, and the net return due to nitrogen for all three experiments for the two functions are shown in Table 5.

The functions estimated by the first 4 or 5 rates in the Hardy experiment fail to approximate the estimated functions obtained when all 12

TABLE 5. MEASURES OF COMPARISON OF ESTIMATES FROM FUNCTIONS BASED ON SUBSAMPLES OF RATES, THREE 12-RATE EXPERIMENTS, HARDY, NEB., ONTARIO, ORE., AND PROSSER, WASH.

Quadratic square root

TABLE 5. MEASURES OF COMPARISON OF ESTIMATES FROM FUNCTIONS BASED ON SUBSAMPLES OF RATES, THREE 12-RATE EXPERIMENTS, HARDY, NEB., ONTARIO, ORE., AND PROSSER, WASH.

	Exponential				Quadratic square root			
	Sums of squares of deviations of 12 treatment means[a]	Most profitable rate	Yield at MPR	Net returns due to nitrogen	Sums of squares of deviations of 12 treatment means[a]	Most profitable rate	Yield at MPR	Net returns due to nitrogen
		Pounds	*Bushels*	*Dollars*		*Pounds*	*Bushels*	*Dollars*
Hardy, Neb.								
(1) 12-rates	160.11	164.0	121.6	116.24	388.35	180.0	121.9	117.62
(2) 1st 4 rates	4,169.97	261.6	155.1	146.26	36,142.11	50.0	77.4	69.22
(3) 1st 5 rates	534.42	196.3	130.7	184.88	12,256.56	4,887.0	1,282.3	1,031.23
(4) 1st 7 rates	355.50	186.6	128.0	120.69	3,748.23	768.0	229.6	176.00
(5) 5 rates (0, 4, 8, 12, 16)	179.10	156.7	120.0	112.72	428.13	166.0	120.3	112.16
(6) 6 rates (0, 4, 6, 9, 12, 16)	168.84	159.4	120.6	113.15	428.67	166.0	120.8	113.14
Ontario, Ore.								
(1) 12 rates	254.79	173.0	142.7	88.71	601.65	182.0	141.9	89.04
(2) 1st 4 rates	13,680.99	1,109.0	394.3	295.23	48,227.85	.21	64.5	−.02
(3) 1st 5 rates	21,808.17	1,077.0	411.2	324.53	33,260.76	.32	64.4	.65
(4) 1st 7 rates	2,157.03	279.0	170.0	108.37	9,492.93	161.0	152.0	100.17
(5) 5 rates (0, 4, 8, 12, 16)	282.51	167.0	140.9	82.61	657.09	164.0	139.2	81.38
(6) 6 rates (0, 4, 6, 9, 12, 16)	309.24	159.0	139.9	82.13	707.85	158.0	139.4	78.78
Prosser, Wash.								
(1) 12 rates	307.17	274.0	140.9	142.30	695.39	336.0	143.9	143.78
(2) 1st 4 rates	3,581.19	349.0	169.0	168.15	97,333.65	17.0	34.3	28.67
(3) 1st 5 rates	874.08	239.0	130.0	131.17	17,808.03	3,073.0	877.7	752.29
(4) 1st 7 rates	334.80	263.0	138.2	138.63	5,502.33	2,131.0	425.2	261.91
(5) 5 rates (0, 3, 6, 9, 13)	321.84	272.0	141.5	139.52	954.99	286.0	140.1	136.58
(6) 6 rates (0, 2, 4, 6, 8, 11)	356.22	275.0	138.3	132.35	774.09	363.0	145.8	131.68

[a] Sums of squares based on 12 treatment means. Sums of squares in table 1 based on all observations.

rates are used, as shown in figures 2 and 3. The estimated functions did fit that portion of the data on which the estimates were based more closely than did all 12 rate estimates. However, these estimated functions deviated considerably from the 12-rate estimates at levels of fertilizer applied above the highest rates used for the subgroup estimates —in general, the segment of economic significance.

Also, the related estimates of the most profitable rates, yields, and net returns to nitrogen deviate considerably from the 12-rate estimates. In some instances, extremely high rates of nitrogen are recommended for application—greater than reason would permit. In other instances, the most profitable rate of nitrogen was estimated to be close to zero for an experiment that produced an increase in yield from the zero level of application to the 40-pound level of application of 25.8 bushels. With the increased yield valued at $36.12, and the nitrogen costing $6.00 for the 40 pounds (corn priced at $1.40 per bushel and nitrogen priced at $0.15 per pound applied in the field) an increase in income of $30.12 is obtained by applying the nitrogen.

Reducing the size of the experiment by applying a smaller number of rates at low levels of fertilizer does not consistently provide satisfactory estimates, as shown by these subgroup estimates. Such experiments would not be sufficiently complete to provide reliable recommendations to farmers.

The estimated functions based on the subgroups of 5 and 6 rates distributed over the complete range of rates of the experiment provided estimates that closely approximated the results obtained from the 12-rate estimates. The deviations among these estimates are not so large but that they could have occurred by chance when compared with the experimental error of the complete experiments. Many experiments have been designed to test the quadratic effect of a plant nutrient on yield without fitting the regression function. To simulate a similar experiment, 5 rates representing a geometric progression were specified and the exponential and quadratic-square-root functions were fitted. In none of the three situations did the estimates approximate those obtained from all 12 rates as well as did those from 5 rates representing an arithmetic progression distributed over the range.

Functions were estimated from subgroups of rates in which the highest rate is above 120 pounds. As the data in that range are approaching a maximum yield and do not evince a tendency for increased nitrogen to reduce the yield, the estimated functions approximated a straight line, parallel to the horizontal axis. Such portions of the experiment might provide considerably more information toward procedures of reducing the number of rates if such estimates were made with the zero level of nitrogen application included as one of the rates.

Summary

By using data from three experiments designed to study the application of nitrogen fertilizer to irrigated corn in the western states, comparisons have been made among estimates obtained from five mathematical functions fitted to the data. In general, a form of the exponential ($Y = M - AR^x$) and the "quadratic-square-root" form ($Y = a + b_1\sqrt{X} + b_2X$) of the general quadratic were better fits to the experimental data than the Cobb-Douglas, or quadratic. The Gompertz function was superior in "fit" but economic estimates were more difficult to obtain.

Under conditions that prevailed during these experiments, the exponential and quadratic-square-root functions are the better functions for economic estimates. The three experiments used provide little evidence for a preference between the two mathematical functions based upon data covering the full range of the experiments. The ratio of successive yield increments, measured by *R* in the exponential function, is also approximately constant for the quadratic square root.

With little differences between these two functions evidenced by other tests, a preference for one versus the other might be based on the computational complexity. To obtain least-squares estimates of the parameters in the exponential function, an estimate must be made of *R*. By several iterations this value is adjusted until the least-squares estimates are obtained.[4] For the quadratic square root function, the direct method of least-squares multiple-regression estimation is available, with only a single series of computations needed. Since each iteration of the exponential involves essentially the same work, for a single input factor, as the complete computation for the quadratic square root, it is obviously easier to make the computations for the latter function. A graphic procedure for fitting the exponential function has been developed that provides, with less work, satisfactory estimates for practical recommendations of the most profitable amount of a fertilizer nutrient to apply.[5]

In designing the experiments, evidence shows that fewer than 12 rates of application may be applied. They should be not less than 5 or 6 for a single input factor, with a minimum of three replications, and should be distributed over a range of rates such that little increase in experimental yields at the higher rates of application are obtained. To determine this range, a few exploratory experiments such as these three may need to be performed.

[4] See W. L. Stevens, "Asymptotic Regression," *Biometrics* 7:247-267, 1951. A graphic procedure for obtaining the initial *R* is outlined in *A Graphic Method of Interpreting Fertilizer Response* by D. B. Ibach, USDA Agr. Handbook No. 93, 1956.

[5] D. B. Ibach, *op. cit.*

REFLECTIONS ON AGRICULTURAL PRODUCTION, OUTPUT AND SUPPLY

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TELL me what the supply of farm products will be five or ten years from now, and I shall give you meaningful answers to the more important economic problems of agriculture. This is not an idle promise. Most of the relevant knowledge of consumption and demand is at hand and the important economic problems of agriculture call primarily for adjustments in production. One is not asking for the impossible. It is not like asking for a fulcrum with which to move the world. There are, of course, many who talk and act in the research they undertake as if the U. S. farm problem could be resolved by adjustments in the demand. They are climbing a mole hill, not the mountain awaiting to be scaled.

It will be said, however, "Surely much progress has been made in production economics." It is true that simple, old-fashioned budgeting has been replaced by sophisticated production functions, and the journals runneth over with "results" from linear programming, a new apparatus that is turning out, thus far, an undigested mixture of a few insights and many "numbers" that do not make sense. These particular studies in production economics, however, tell us very little about the supply of farm products. They contribute little for two reasons. Many are about things that are trivial. Those that take a larger bite concentrate on conventional inputs. These, it so appears, can tell us comparatively little about changes in the supply. As a qualification, there is some research work that is in way an exception: most of it was formerly in the old BAE and now in the Agricultural Research Service.[1]

The unresolved problem of the "inputs" explaining the increase of the supply goes far beyond agriculture, however. It is indeed a fundamental matter, at the heart of any approach to explain economic growth. How is growth in output, for example, achieved? Theorizing based on savings and capital formation, on disguised unemployment or on indus-

* I have benefited from a number of comments and suggestions that I received on an earlier draft of this paper from D. Gale Johnson, A. C. Harberger and Zvi Griliches.

[1] A number of titles come to mind at once: *Technology on the Farm, Changes in American Farming, Changes in Farm Production and Efficiency,* and the older *Farm Production Practices, Costs and Returns,* and others. In an earlier draft of this paper I had included some results from data made available to me by Dr. Wylie D. Goodsell, drawn from the studies of *Farm Costs and Returns of Commercial Family Operated Farms by Type and Location.* As I proceeded, however, it became clear to me that these data go beyond the task at hand; and I shall, therefore, come back to them on another occasion.

trialization, has not proven fruitful. Each of these notions flounders on the increase in production and for the same reason, so it would appear, as in agriculture; namely, *growth in output cannot be explained satisfactorily by an analysis which is based on conventional inputs.*

Moreover, our farm problem of too much agricultural production, and that in poor countries of too little, are basically of the same species, because both are problems pertaining to economic growth. In our case the task may be one of adjusting to a rapid growth of output which, if we understood it, could be checked or taken in stride by planning to adjust to it. Whereas in poor countries the task is usually one of living with too little growth in output—importantly, in most cases, in agriculture, which, if understood, could be made to increase at a more rapid rate. The nature of economic growth in both cases turns out to be the unresolved problem of explaining the additional output with which we started.

I. *Demand and Supply Compared*

In the case of the demand, we analyze particular activities of households, and in the case of supply, activities of firms. For households we seek to determine the underlying consumption functions, and for firms the production functions. Both concepts are based on received theory of long standing. Why is it, then, that the knowledge we have been able to amass about the demand, say, for food is on a much stronger footing empirically than is the equivalent knowledge about the supply of farm (food) products? We know, for instance, that the demand for food of consumers at retail has relatively low price and income elasticities. We are quite confident that both of these elasticities will continue to be relatively low; and that five or ten years from now they will have about the same values as they have at the present with one minor qualification; namely, that as we become somewhat richer as a people these elasticities are likely to become a little more inelastic over time. We also know, in addition to these price and income elasticity values, that the aggregate demand for food is some function of the number of consuming units. Thus the growth of the demand can be linked to growth of population.

By comparison we know much less about the supply of farm foods. We have no meaningful estimates of the price elasticity of the supply. We theorize that for a large sector like agriculture the supply is likely to be quite inelastic in the short run, because it is difficult to shift many resources out or into agriculture, and that the supply is more elastic given time to make such inter-sector shifts and given time for producers to convert the relatively fixed inputs into variable inputs. There once

were some fairly useful "farmer response to price" studies and the well known "corn-hog ratio" studies that cast some light on the supply of particular farm products.

Presently, however, the main effort is to determine the underlying production functions of farms. This leads one to ask: Suppose we knew the production functions of each and every farm, could one with this knowledge indicate even approximately what the aggregate supply of farm foods is likely to be five or ten years hence? The answer appears to be in the negative, because, as I shall show later, these functions are based on a *set of conventional inputs* and only a minor part of the shift of the supply to the right that occurs in agriculture comes from such additional inputs.

The striking difference in what we know about the demand and what we know about supply has not come about because one has received our attention while the other has been neglected. The difficulty runs much deeper than this. For a function to be useful it must either be stable over time, or we must be able to predict how it will change. The stability of the function underlying the demand is dependent upon what happens to "tastes" and in the case of supply upon "technology." We observe, however, whereas tastes remain fairly constant, technology does not. Therefore, unless we can predict the changes in technology it follows that production functions, linear programming models and input-output models are all comparatively "useless" in a logical, positivistic sense.[2]

There are, therefore, two basic factors that go a long way in accounting for the wide disparity in our present knowledge about demand and supply. Both of these factors indicate that the demand concept with which we work rests on a fairly stable foundation, whereas the supply concept stands on shifting sand.[3] First there is the fact that in the case of households, the tastes underlying consumption, on which the price

[2] If this statement is a valid characterization of what is happening in production, one may easily overrate the value of these observed functions to farmers as useful farm management information. How can a farmer benefit from knowledge about yesterday's or today's production functions if they are obsolete tomorrow? The information which he would find valuable would consist of knowledge about the nature of the change of the production function that is underway applicable to his farm.

[3] This statement about the demand does not imply that we can predict either the growth in population or the rise or fall in per family or per capita income. But it is not the task of a theory of demand to explain population and income. Our statement, however, does imply that for a particular population; namely, for the consumers of the United States buying food at retail, there are observable price and income elasticities that have remained fairly stable.

In the case of supply, we also need to point out that this statement does not imply that we can predict the growth of the labor force, the additions to the stock of reproducible capital and the further "discoveries" of non-reproducible factors; this is not the task of a theory of supply. What our statement does say, however,

elasticity of the demand for food depends, have stayed remarkably constant for consumers at retail for five or ten years and longer.[4] In the case of farms, on the other hand, the technology employed in production, on which the price elasticity of the supply of farm products depends, have been subject to many important changes during a decade and less. Secondly, and closely related, when it comes to determining the way the demand and supply schedules shift over time, the consuming unit has been a relatively stable institution for consumption. This stability has made it possible and comparatively easy to take account of growth in population by simply adding the appropriate number of additional consuming units. For many purposes even a per capita demand multiplied by the size of the population, while quite rough and ready, has proven fairly useful. On the supply side, however, the producing unit in farming, and in other sectors as well, is not on a comparable footing. From a change in the number of firms one cannot infer changes in output; nor can one proceed the other way around. The supply schedule of farm products needs not and has not been riding to the right on the backs of more farms. Then, too, useful knowledge about the scale of firms having any predictive value is not at hand. Scale considerations that may be sufficient for our purposes are still among the unknowns. Nor can one get far on the supply side (at any given relative supply price) by taking the additional inputs of the conventional type to determine additional output, as we shall show.

II. *Additional Output and Additional Conventional Inputs*

At what supply price will a substantial increase (let this be 20 percent) in output be forthcoming over a span of a decade?[5] There are studies

is that with a particular set of such resources at hand we are not able to observe any dependable price elasticities for the supply, or with particular increases in such resources, we are not able to observe any stable relations between such increases in resources and increases in production.

[4] As already noted in the demand for food, the income effects on which the income elasticity depends also appear to be remarkably stable. The demand, however, is not free of uncertainty considerations which, of course, also abound in the case of the supply. The recent advance in distinguishing between the "permanent" and "transitory" components in income adds further to our understanding of the demand. The theoretical underpinning of this advance and its relevance in organizing consumption and savings data will appear in Professor Milton Friedman's book, *A Theory of the Consumption Function*, to be published by the National Bureau of Economic Research.

The possibility remains that developments can take place at some future time that could alter substantially the now existing price and income elasticities of this demand. Such possibilities are not ruled out in what has been said here.

[5] In putting this question we assume that the increases in total labor force, in the stock of reproducible capital and in the non-reproducible factors have been or may be estimated and that one proceeds to determine the answer with such estimates at hand.

with estimates showing that the returns to scale in farming are approximately constant. Suppose, also, no limitational inputs would come into play in increasing output by no more than a fifth. Diminishing returns would not show its ugly head. But of what use is such knowledge? Surely no one who has even a casual acquaintance with agriculture would be foolhardy enough to predict that it will take a fifth more

TABLE 1. RECENT CHANGES IN OUTPUT AND INPUT IN AGRICULTURE IN THE UNITED STATES

Period	Output (percent)	Input (percent)	Proportion of additional output accounted for by additional input[e] (percent)
(1)	(2)	(3)	(4)
1900–1920[a]	25	18 to 21	72 to 84
1910–1920[b]	15	17	100[f]
1923–1929			
I[a]	7	4	57
II[b]	7	3.7	53
1930–1940[b]	16	−5	0
1940–1948			
I[a]	25	6.5[d]	26
II[c]	25	5	20
1930–1950[c]	39	1	4
1950–1955	12	n.a.[g]	n.a.[g]

[a] D. G. Johnson's estimates in "The Nature of the Supply Function for Agricultural Products," *American Economic Review*, Vol. 51, September 1950. For 1900–1920, the output is based on "agricultural production for sale and home use on farms"; for the other periods the recent estimates of "farm output" are presented here.

[b] My estimates based on data obtained in preparing Chapter 7 of *Economic Organization of Agriculture*, McGraw-Hill, 1953, using, however, 1935–39 prices for the weights. The input series based on these weights has not been published.

[c] Same source as in footnote b above, using 1946–48 input prices as weights. This input series appears in Table 7-5 of my book.

[d] Johnson's input estimates for 1940–48 were based on the old labor input series, which substantially understated the decline of this input in agriculture and which for 1940–48 indicated an increase in input of 10 percent or less. Using census estimates of farm labor that are now available, however, the increase in input becomes 6.5 percent, as is shown here.

[e] With "constant" returns for additional inputs.

[f] Implies diminishing returns for the additional inputs.

[g] Not available.

inputs to achieve a 20 percent increase in output during the decade. An engine of analysis that is restricted to *conventional inputs* simply does not have the power to tell us what the supply of farm products will be in future periods. Additional inputs of the kind that are commonly placed in our conceptual boxes—labor, land, other capital, and current production items—account for only a part and, as it appears, for a declining part of the increase in agricultural output.

The estimates in Table 1 are based on two different methods for determining changes in aggregate input. The output data, however, are

essentially the same: either "agricultural production for sale and home uses on farms," or "farm output," as these indexes have been prepared by the U.S.D.A. The particular base period is not of as much concern for the output index as for the input index because changes in the relative prices of farm products have not been so important. In the case of the aggregate input, the "I" estimates are those of Johnson[6] based on production functions for agriculture assuming constant returns to scale and marginal productivities of resources equal to average net productivities.[7] Estimates "II" were derived by aggregating eight sets of production inputs using 1935-39 input prices for the periods 1910-20, 1923-29 and 1930-40, during which time the relative changes in these input prices were not considered to be of major importance.[8] Later, as the price of labor rose sharply relative to most other inputs, 1946-48 input prices were used to weight the several inputs. The similarity in the magnitudes obtained by using these two methods in determining the change in input in agriculture is noteworthy. The two estimates do not appear to be inconsistent one with another; on the contrary, they reinforce each other.

The estimates in Table 1 may be interpreted as follows: From 1900 to 1920 all—or virtually all—of the increase in output may have been achieved by additional inputs. There may even have been some diminishing returns for the additional inputs against nonreproducible factors. See column (4). From 1923 to 1929, only about one-half—or a little more—of the increase in output appears to have been achieved by additional inputs. During the depression years, 1930 to 1940, none of the increase in output seems to be explained by additional inputs. One observes that although output increased 16 percent, the input fell by 5 percent. The war years called forth substantially more output, yet from 1940 to 1948 perhaps only about a fifth to a fourth of the increase in output can be accounted for by additional inputs.

The declining importance of additional inputs in the expansion of agricultural production in the United States is the outstanding fact that emerges from these data.

Moreover, this observed "declining importance of additional inputs"

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[6] D. Gale Johnson, "The Nature of the Supply Function for Agricultural Products," *American Economic Review*, Vol. XL, September 1950.

[7] *Ibid.*, p. 559, See fn. 32 for a procedural note giving two different functions, one linear and the other linear in the logs. The estimate for linear in logs indicated that the input increased 18 percent from 1900 to 1920. The changes in marginal products with 1900 = 100, if product prices had not changed, imply the following changes in marginal physical products: labor + 18 percent, land + 3 percent, capital — 9 percent, and current inputs — 41 percent.

[8] The eight sets of inputs appear in Table 7-5 of my book, *The Economic Organization of Agriculture*, New York: McGraw-Hill, 1953, using 1946-48 price weights. The data using 1935-39 input prices as weights have not been published. Source of these data is set forth in Chapter 7 of my book.

in achieving additional agricultural output is not unique to the circumstances of the United States or to other highly developed countries. Moore's studies, although based on less satisfactory data, even so convince one that Brazil and Mexico have been experiencing supply developments similar to our own. Table 2 indicates that in Brazil and Mexico only about one-half of the large increases in output from 1925-29 to 1945-49 have come from additional inputs. Ballesteros' study of the Argentine goes deeper and makes clear that from 1908 to 1920 about seven-tenths of the rise in output in agriculture may be explained by

TABLE 2. RECENT CHANGES IN OUTPUT AND INPUT IN AGRICULTURE IN BRAZIL, MEXICO AND ARGENTINA

Country and period	Increase in		Proportion of additional output accounted for by additional input[f] (percent)
	Output (percent)	Input (percent)	
(1)	(2)	(3)	(4)
Brazil[a]			
1925–29 to 1945–49	54[c]	30[d]	55
Mexico[a,b]			
1925–29 to 1945–49	60	27[e]	45
Argentina[g]			
1908–1920	24	17	71
1920–1940	55	12	22
1940–1952	−12	−7	—

[a] Clarence A. Moore's estimates. For Brazil, *Agricultural Development in Brazil*, unpublished Discussion Paper No. 54-044, Room 417, Social Sciences University of Chicago, growing out of the TALA studies. For Mexico, "Agricultural Development in Mexico," *Journal of Farm Economics*, Vol. 37, February 1955.

[b] Restricted to agricultural crop production.

[c] Moore's output index I, based on 1937 prices. His output index II rose 56 percent.

[d] Moore's input index II, based on 1940 input prices. His input index I rose 28.7 percent.

[e] Moore's input index II, based on 1940 input prices. His input index I rose 24.7 percent.

[f] With "constant" returns for additional inputs.

[g] Marto Ballesteros' study, *The Economic Development of Agriculture in Argentina, 1908-1954* (in process). These data are from Table 6-3 of his paper, No. 55-035, Room 417, Social Sciences, University of Chicago.

additional inputs, this being not unlike the experiences of U. S. agriculture at the same time. However, only a fourth or less of the big increase in output from 1920 to 1940 came from additional inputs of the conventional types. Then came the great impairment of the economy of the Argentine: from 1940 to 1952 the output of agriculture fell more than a tenth while the input appears to have dropped about as much.[9]

We also now have from Johnson's study comparable data for the

[9] The input data, however, present difficulties of a kind that make one believe that the drop may have been somewhat greater than this.

U.S.S.R. Agriculture in the U.S.S.R. achieved very little increase in production from 1913 to 1928; about one-half of this increase may be explained by additional input. During the next decade, however, the rise in output was about 15 percent and this was achieved without additional input, thus not unlike our own experience from 1930 to 1949. Johnson's estimates indicate, however, that since then, that is from 1938 to 1952, the additional output has not exceeded the additional input.

TABLE 3. RECENT CHANGES IN OUTPUT AND INPUT IN AGRICULTURE IN THE U.S.S.R.[a]

Period	Increase in Output (percent)	Increase in Input (percent)	Proportion of additional output accounted for by additional input[b] (percent)
(1)	(2)	(3)	(4)
1913–1928	8	4	50
1928–1938	15	0	0
1938–1952	20	20	100

[a] Source: D. Gale Johnson, *A Study of the Growth Potential of Agriculture of the U.S.S.R.*, RM-1561, October 1955, The Rand Corporation, Santa Monica, California.
[b] With "constant" returns for additional inputs.

To maintain one's bearing, it may be helpful to take a brief look at what has been happening to the U. S. economy as a whole on the score of its input and output. Solomon Fabricant,[10] drawing upon the wealth of data of the National Bureau of Economic Research, has reported that during the eight decades from 1868-1873 to 1949-1953, the growth in per capita output in the United States increased about fourfold, which represents an annual rate of 1.9 percent compounded. By adjusting for the increase in population, and for the relatively small increase in input per capita, one finds that the implied output rose from 100 (for 1869-73) to 1,950 (for 1949-53), while the additional input rose from 100 to about 468 during the same period. Accordingly, the additional inputs, assuming "constant" returns, account for only about one-fifth of the additional output.[11]

[10] Solomon Fabricant, *Economic Progress and Economic Change*, a part of the 34th Annual Report of the National Bureau of Economic Research, New York, May, 1954. In deriving the aggregate input from Fabricant's per capita data, population was taken at 38.5 million for the first period and at 150 million in the second, and the per capita input was increased as reported by Fabricant.

[11] Since this was written, a paper by Moses Abramovitz has been made available to me. This paper "Resources and Trends in the United States since 1870" was read at meetings of the American Economic Association, New York City, December 1955, and appeared in the *Proceedings* of the Association, *American Economic Review*, Vol. XLVI, No. 2, May 1956.

The data appearing in Table 1 of the Abramovitz paper are calculated for 1869-78 and 1944-53. They, however, show the same result, namely that only about one-

From these data and the production experiences they represent, several inferences about the supply appear plausible. Additional inputs of the conventional types have accounted for most of the additional output during some periods, for example, during the early part of this century in agriculture in the United States. Such a close relationship between additional outputs and inputs has been the exception, however, rather than the rule, for we find that much, and probably most, of the more recent expansion in agricultural production has not come from additional inputs of the conventional types. In the main, additional output has not been dependent upon such additional inputs. The link between such conventional inputs and output is, therefore, very weak, too weak to bear the analytical burden of determining the supply. We thus repeat the following statement: If we had known the production functions of each and every farm, say as of 1930 or as of some other recent date, as these are now being determined, that kind of knowledge, along with estimates of the increases of the quantity of conventional inputs employed, would not have given us even a rough approximation of the aggregate supply of farm products that has been produced.[12]

III. *In Search of a Theory of Output Growth*

We would like to know: To the extent that growth in output does not come from additional conventional inputs, *where does it come from?* The facts are strong and stubborn in supporting the inference that much, and probably most, of the growth in output cannot be explained by increases in the size of the labor force and in the stock of reproducible inputs. We have cited Fabricant and Abramovitz who found *four-fifths* of the remarkable economic growth of the United States of the last eight

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fifth of the growth in output can be explained by additional conventional inputs:

Net national product rose 12.25 times
Index of total inputs rose 2.61 times

[12] I do not wish to imply that we should forego working with production functions even though these functions are as a rule subject to important changes. Research based on the assumption that they remain unchanged has made some useful contributions. There are some situations in production where technology and the marginal rates of transformation have stayed fairly constant. Under these particular circumstances useful estimates are possible as to the effects of changes in the relative prices of inputs upon production (or what should be produced), and as to the effects of changes in relative price of outputs upon production where one or all inputs can be used in producing the several outputs. Glenn L. Johnson has given us an excellent statement of these results. These achievements in production economics should not be underrated or lost sight of, especially in view of the important changes that have been occurring in the relative prices of inputs used in farming. These achievements, however, cast little or no light on the expansion of the supply of farm products where incremental output substantially exceeds incremental input. See Glenn L. Johnson, "Results From Production Economics Analysis," *Journal of Farm Economics*, Vol. 37, May 1955.

decades unexplained by additional inputs. Fabricant explained it by an appeal to "improvements in national efficiency." But what is that?

The question remains: Where does all of this unexplained increase in output come from? Is the four-fifths beyond economics? If that is the case, in view of the importance that countries and individuals attach to more output, it is high time students in other fields took over. If economic analysis, however, can explain a substantial part of this growth, why has it failed to do so?

Clearly some stock taking is called for. The idea of economic progress is not wholly new: John Stuart Mill devoted all of Book IV of his famous synthesis of classical economics, *Principles of Political Economy,* to this topic. Allyn A. Young's well-known paper dealt with "Increasing Returns and Economic Progress." More recent theorizing about economic development, in the main, has been tied either to savings and the formation of conventional capital (items), or to that of disguised unemployment. These views of the problem have been part and parcel of the intellectual aftermath of the mass unemployment of the thirties. Neither of them appears to have much relevance to the kind of economic growth that one observes in most countries; that is, to the growth in output where the link between incremental input and incremental output has become tenuous.

There are, so it would appear, four developments at work changing the supply that are not represented among the supply variables in current studies. They are either omitted or viewed as ad hoc developments beyond the reach of economic analysis. First, there are the production effects of the greater division of labor dependent upon the extent of the market. This is most certainly not a new concept. On the contrary, the launching of "systematic economics" by Adam Smith was keyed to the division of labor. The concept, nevertheless, has continued to remain surprisingly vague and no one to my knowledge has used it as an analytical tool in empirical research. Secondly, there is the improvement of the *quality* of people as productive agents. Adam Smith gave much credit to the role of specialization in improving the dexterity and skill of workers. He thus related this development mainly to the division of labor. Marshall rated new knowledge very high and considered it the most powerful engine of production. The rise in knowledge of workers and of entrepreneurs (let me add also the advance in knowledge of those important civil servants who administer the monetary and fiscal and other economic controls of government) is nowhere taken into account. Changes in the labor force are measured by the size of the labor force, either by taking the numbers of people doing "productive" work or by calculating the numbers of hours that they work (altogether). All

changes in "quality" of this, the most important input of them all, have been completely neglected.[13]

Thirdly, we come to inventions and all manner of new and better techniques of production. This development has become known as advance in technology. Adam Smith, again, saw it (mainly) as a function of the division of labor. Marshall included it under knowledge that was useful. A vast literature has appeared in recent decades ascribing most of the rise in "output per unit of input" to advances in technology. Surprising little analysis has been undertaken, however, to determine the (economic) developments related to a particular new technique. No one, as far as I know, has ventured to treat new techniques in such a way that one might predict their appearance, their adoption, or the economic effects once they have been adopted.[14] Fourthly, there remains the concept of diminishing returns, old and revered, of additional inputs against whatever nonreproducible factors exist. If all factors were reproducible, the observed expansion in output (per additional input) would have been somewhat greater than it has been; diminishing returns is, in this sense, a drag on economic growth varying from country to country and from sector to sector in a particular economy depending upon the nature and magnitude of the nonreproducible factors. This concept, old as it is, has been put to little use in supply analysis.

These exploratory observations would seem to indicate that several important factors have been neglected in studying economic growth and the increases in production on which such growth rests. It is clear that output linked to conventional inputs does not provide us with a satisfactory scheme for analyzing this kind of a development.

The analytical task, as I see it, is to re-establish a strong and satisfactory linkage between input and output over time. In our efforts to do this, we would do well to place before us and keep in mind the characteristics of an *ideal input-output formula* for this purpose. It would be one where *output over inputs*, excluding of course, changes in their quality, stayed at or close to one. The closer we come to a one-to-one relationship in our formulation the more complete would be our (economic) explanation.[15]

Our belief is that we can approximate this ideal formulation by in-

[13] The changes that occur in the quality of inputs represented by reproducible capital are, also, not taken into account fully, although the consequences of this neglect is probably less important than that in the case of "labor."

[14] Such a study is now underway at the University of Chicago. Zvi Griliches is concentrating his research on developments related to hybrid corn in the United States.

[15] I am indebted to Zvi Griliches for viewing the problem before us in this way.

troducing two important changes in inputs, changes that are being neglected. We shall treat these changes in inputs, when we consider the economy as a whole, as two neglected inputs. Let us then start with the economy, leaving the firm for later, and proceed to represent these two neglected inputs and say a word or two about the activities that are required to "produce" them.

The two neglected inputs may be represented (1) by the new techniques that are adopted in production and (2) by improvements in the labor force, that is, in the quality of the people who engage in production. We therefore need to examine the activities that come into play in "producing" these two inputs. Let us assume that it takes capital and effort to improve the quality of the labor force and to "discover" and develop new techniques of production. The particular activities are fairly apparent. They are, for example, education, training to impart skills some of which may be acquired on the job, and facilities and services related to health and so on, for the one. In the case of the other, we have centers where scientists work, research institutes, agricultural experiment stations and such similar "agencies." It is not necessary that the allocative process committing capital and effort to these activities have a strong economic orientation. Where they are so oriented, however, one would expect to find the rates of return in these activities over the long run to become about the same as they are on capital and effort allocated to produce the conventional inputs. Whether these rates of return are high or low relative to those realized from capital and effort used to produce the conventional types of inputs, is, however, strictly a question of fact.[16] If there are observable inequalities in these rates of return, the opportunity would exist to increase the national product by appropriate reallocations of the available resources.

There can be no doubt that these particular activities exist and that in the United States a substantial quantity of capital and effort is being allocated to them. To analyze them as production activities presents no new analytical problems. In practice, however, there are some difficulties, especially in identifying and evaluating the "product." In the case of those activities that are organized to produce new techniques of produc-

[16] From observations and study of the 20 Latin American republics and of Puerto Rico, I would venture the guess that in these countries the marginal (and average) rates of return on capital and effort allocated to improve the quality of people and to raise the productive arts far exceeds that on reproducible capital of the conventional types. Moreover, it appears that those countries with strong economic growth characteristics are precisely the ones that have been "investing" their available capital and effort accordingly. See my lectures at Cornell University, March, 1956, *The Economic Test in Latin America*, to be published by the School of Labor and Industrial Relations of Cornell University.

tion, it is helpful to think of them as one would in drilling for oil where most holes turn out to be dryholes. The economics of such drilling operations is, nevertheless, straightforward when they are viewed as producing firms working on some probability bases. So it is with organized research.

Let us now look briefly at the firm where these two neglected inputs enter and play important roles in increasing output. The best way to represent the two inputs under consideration is to treat each of them as introducing a change in quality of one or more of the conventional inputs. In the case of improvements in the labor force, a change in quality is what we need to identify and evaluate. So too, in the case of a new technique; for example, the differences between a bushel of open-pollinated corn and a bushel of hybrid corn may be represented as a qualitative difference. And, so it is with other new techniques.

We observe everywhere throughout the economy that the marginal (and average) productivity of the human agent has been rising. The human agent, viewed as an input, has come to be worth increasingly more to the firm, in what the firm can and does pay for the services of this agent. This development in itself creates a strong presumption that the quality of this input has been improving. The traditional concept of labor in studying production of merely counting the number who work, or the number of hours worked, fails completely to take account of changes in quality of this most important input of all. The studies of Zeman[17] and Willett[18] of Negro workers represent a major advance in research to determine the "market value" of the variations in the quality of this input. Johnson's[19] earlier study of the nonfarm wages of recent farm migrants also comes to grips with an important aspect of this problem. In examining the income disparity among communities some time back, I gave much weight to the *conditions that determine the abilities of a population to produce.*[20, 21]

In the case of a new technique of production, we may look upon it

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[17] Morton Zeman, *A Quantitative Analysis of White-Nonwhite Income Differentials in the United States* (to be published by the University of Chicago Press).

[18] Joseph W. Willett, *An Analysis of the Incomes of White and Negro Commercial Farm Operators in the Southern States,* a manuscript at the University of Chicago.

[19] D. Gale Johnson, "Functioning of the Labor Market," *Journal of Farm Economics,* Vol. 33, February 1951.

[20] See my, *The Economic Organization of Agriculture,* New York: McGraw-Hill, 1953, Chapter 10.

[21] In a recent paper "Agriculture's Advancing Productivity" read before the National Farm Institute, Des Moines, Iowa, on February 17, 1956, Sherman E. Johnson stressed the importance of basic education in the transformation of American agriculture (see page 5).

as another particular input and as an input that is qualitatively better than the one it replaces. We have already suggested this possibility by comparing a bushel of open-pollinated corn with a bushel of hybrid corn.

Whereas the direction and even the magnitude of the economic effects of a new technique upon the price of the product and upon other input prices present no new analytical problems, there remains a most difficult index number problem in pricing the improvement in the quality of this input. Take, for example, the introduction of hybrid corn. Let us assume that farmers know from their past experiences that they can "count on" say $1.10 of returns on each $1.00 of open-pollinated corn that they may plant. There now is available to them an alternative input, the hybrid corn. Farmers in some places, say in the heart of the corn belt, find that it will contribute as much as $10.00 per $1.00 of this (new) input. Farmers in other places, however, find that this alternative input will not produce for them per $1.00 expended any more than they have been realizing by using open-pollinated corn. In still other areas the rate of return on the hybrid corn available to them may turn out to be less than on the established open-pollinated varieties. The direction of the implications of these differences in returns to the decisions and the activities of these firms are clear enough. One also may trace such effects of hybrid corn upon the relative price of corn, upon the value of land in the different places used to produce corn, and upon the redistribution of the corn acreage among these places, by traditional partial equilibrium theory and process analysis. But the index number problem of assigning weights to this (new) input in the various places requires major analytical attention.[22]

Conclusion

From these reflections we are prepared to say that our knowledge about demand is on a much stronger footing than is our knowledge about

[22] After a new equilibrium has become established in the places where hybrid corn turned out to be qualitatively better (more productive) than the open-pollinated corn, the additional productivity would be redistributed and presumably exhausted in a relatively lower product price and in a redistribution of the rewards among inputs more favorable to the nonreproducible factors with the new input "earning" no more than its cost. But this would not be the case at the outset when the hybrid corn was being introduced. A difficulty in determining a "price weight" in measuring the new input may be seen in a comment that Zvi Griliches has made: namely, suppose that instead of a competitive hybrid corn seed industry we had had a perfect discriminatory monopoly, and that as a consequence the price of the hybrid corn in each place had been set at a level that would have made it just profitable to shift to hybrid corn. This would make the measure (the price weight) of the new input depend upon the monopoly (or competitive) characteristics of the market.

supply. Our analysis of supply fails because so much of the increase in output in agriculture and, alas, in the rest of the economy, cannot be explained by additional inputs of the conventional types. This failure to explain much, and probably most, of the additional output that we have been enjoying is strongly supported by data now at hand. The analytical task is to re-establish, if we can do so, a firm link between additional output and additional input. The ideal input-output formula would be one where output over input stayed at or close to one. Our proposal is that we can approximate this ideal formulation by introducing two major neglected inputs, namely, the improvement of the quality of the people as productive agents and the raising of the level of the productive arts. In studying the functioning of the economy as a whole, both of these "neglected inputs" require capital and effort and, therefore, the activities that create them may be analyzed as production activities. At the level of the firm the way to bring these changes in inputs into the analysis is to treat them as improvements in the quality of what we have called the conventional inputs. The index number problem, in this case, of determining the weights for these qualitative differences in the inputs will demand major analytical attention.

ISOQUANTS, ISOCLINES AND ECONOMIC PREDICTIONS IN DAIRY PRODUCTION*

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SEVERAL papers have been written providing hypotheses of the nature of isoquants and isoclines in dairy production. However, physical experiments designed to allow prediction of these quantities have not been available previously. The study by Jensen and others was an attempt to provide estimates of a single-line input-output curve[2] The Jensen study probably best provided prediction of a ridgeline of the isoquant family, defining the limits of the cow's stomach capacity and hence a path of feed substitution ratios equal to zero. It was not, of course, designed to allow prediction of an isoquant map.

This paper reports a study designed to provide prediction of the milk production surface and the quantities associated with it. The study is of a methodological nature designed to provide basic science findings upon which later studies can be built. It has practical application in the sense that dairy nutritionists, lacking experiments and data, have had to make recommendations assuming a production function homogeneous of degree one. The study also has practical application in the sense that it provides flesh for the noticeably bare skeletons to which every graduate student is subjected in his economic theory and econometric courses. Finally, it is an example of interdepartmental cooperation making use of basic concepts from both dairy nutrition and economics.

Nature of Experiment

Details of the experiment upon which this study is based are reported elsewhere.[3] Only a few summary statements will be included here. The experiment included 36 Holstein cows which were fed four hay-concentrate rations including 15, 35, 55 and 75 percent of net energy intake from legume hay. From date of calving, all cows were put on a 14-day adjustment period and then a 50-day preliminary period in which they were fed the fixed feed ratio of seven pounds of hay to four pounds of

* Journal paper J-2899 of the Iowa Agricultural Experiment Station, project 1135.
[1] Professor of Economics, Research Associate in Economics, Research Assistant in Dairy Husbandry, and Professor of Dairy Husbandry, respectively.
[2] Einar Jensen, *et al. Input-Output Relationships in Milk Production.* U.S.D.A. Tech. Bul. 815, 1942.
[3] See Solomon Bloom, "Effects of Various Dietary Hay-Concentrate Ratios on Nutrition, Utilization and Production Responses of Dairy Cows." Unpublished Ph.D. thesis. Iowa State College, 1955.

concentrates. Next, they were randomly assigned to particular hay-concentrate ratios for an experimental period of 182 days. Each of the four rations was fed at three levels and a cow of low, medium, and high producing ability was randomly assigned to each treatment. Experimental work was conducted under dry-lot conditions. A fixed ratio of 7 pounds of hay to 4 pounds of concentrates, initiated during the adjustment period, was maintained through the preliminary period. The preliminary period provided the basis for division of cows into high, medium and low producing ability for their subsequent random allotment in the experimental period. In general, the production ability ranges for the animals in terms of 4 percent FCM were as follows: *high* = over 10,500 pounds and over; *medium* = 9,000 to 10,500 pounds; and *low* = less than 9,000 pounds on the basis of a full lactation period. Cows were not fed according to milk produced but at the three fixed levels established before the experiment. In predetermination of the ration levels, it was decided to lower the total quantity of feed as the lactation period progressed, but with hay and concentrates still held in fixed proportions. In addition to the 36 observations for cows, observations were obtained by month for feed inputs and milk outputs. Most of the analysis of the study is based on 6 observations for each cow, or a total of 216 observations. Although problems of autocorrelation exist, these appear to be unimportant in analysis of the results.

Production Function Prediction

Numerous algebraic forms of equations were used in estimating the over-all milk production. Final decision is yet to be made on the most appropriate form. Because of space limitations, however, only two of the more promising algebraic forms will be used in this report.[4] The functions are those listed below where notations have the following meanings:

M is pounds of 4 percent FCM milk produced per cow in each 4-week experimental period.

H is pounds of second-cutting alfalfa hay fed in the same period.

C is concentrate intake per cow in the same period. The composition of the concentrate mix was 27.7 percent no. 2 yellow corn, 34.6 percent rolled oats, 13.9 percent wheat bran, 13.9 percent soybean oilmeal, 6.9 percent linseed meal, and 3 percent salt and minerals.

[4] In certain functions, not presented here, all regression coefficients were acceptable at probability levels of .05 or .01; but seemed inconsistent with known nutritional relationships, and basic logic of nutrition and economics. Inconsistency in this case is defined as linear input-output lines and linear isoquants. Also, some equations, such as a power function, gave linear isoclines through the origin; suggesting that an equally wide range of rations can be used as higher milk levels are attained. Obviously, this condition is not true since the range of possible rations narrows as the maximum level of milk production is approached.

A is cow ability measured in pounds of 4 percent FCM milk produced in the 50-day preliminary period when all cows were fed the standard ration. T is time during the experimental period measured in months of 28 days each.

(1a) $M = 1.630H + 3.1309G + .1497A - 14.2243T - .00039H^2 - 4.3792T^2 - .00119G^2 - .00106HG - .1570GT - .0865HT - 731.76$

(2a) $M = .6601H + 1.4276G + .1553A - .000054H^2T - .000152G^2T - 2.0752T^2 - 157.24$

The percentage of variance explained by the regression variables is 81.3 percent for equation 1a and 80.3 percent for equation 2a. Although some of the standard errors are relatively higher and "t" values are relatively lower equation 1a, it gives isoclines that seem most consistent with the physiological process of milk production. Also, with the linear term for time, isoquants for later points in the production period appear more consistent with current knowledge of nutrition. Hence, with its slightly higher coefficient of determination, equation 1a was accepted, for this experiment, as being most plausible.[5]

Predictions of Relationships

Equations 1a and 2a can be used in predicting feed combinations possible in attaining specified milk levels (isoquants), and in estimating the rate of substitution between hay and grain in the various months. Equation 1b is the milk isoquant based on production function equation 1a where T has been set at 1 and A has been set at 2,492, the mean of the 36 cows in the experimental period. Although 1b only provides estimates

TABLE 1. CORRELATION COEFFICIENTS AND t VALUES FOR EQUATIONS 1A AND 2A.

Equation	R	Values of t in order of b's in equation									
		b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}
1a	.9016[a]	1.94[c]	2.60[a]	9.86[a]	.34	1.14	1.67[c]	1.62[d]	1.10	3.49[a]	2.82[a]
2a	.8960[a]	8.70[a]	13.72[a]	10.22[a]	4.54[a]	5.92[a]	2.65[b]				

[a]P<.01 [c]P<.10
[b]P<.05 [d]P<.20

for the first month (T = 1), similar estimates can be provided for other months by assigning a particular value to T. Equation 1c provides estimates of substitution rates for equation 1b.

Substitution and time-yield equations

Equation 2b and 2c are respectively the isoquant and substitution func-

[5] For other indications of the nature of appropriate functional forms, see E. O. Heady, J. T. Pesek and W. G. Brown, *Crop Response Surfaces and Economic Optima in Fertilizer Use* (Iowa Agr. Exp. Sta. Bul. 424), and W. G. Brown, E. O. Heady, and J. T. Pesek, *Isoquants, Isoclines and Economic Optima in Fertilizer Use* (Iowa Agr. Exp. Sta. Bul. 441).

tions for function 2a, with the values for T and A mentioned above.

$$(1b)\quad H = 1989.36 - 1.3608G \pm (-1288.66)\sqrt{1.8553 + .001355G - .00000073G^2 - .001552Y}$$

$$(1c)\quad \frac{dH}{dG} = \frac{2.9740 - .002384G - .001056H}{1.5437 - .000776H - .001056H}$$

$$(2b)\quad H = 6106.28 \pm (-9250.69)\sqrt{.4850 + .000309G - .000000033G^2 - .000216Y}$$

$$(2c)\quad \frac{dH}{dG} = \frac{1.4276 - .000304G}{.6601 - .000108H}$$

Equations 1c and 2c also can be used to construct isoclines. An isocline shows all possible combinations of feed that result in a given substitution ratio. Hence, they might be looked upon as expansion paths, showing the least-cost rations to be fed as the cow is taken from lower to higher levels of feeding. However, as can be noticed from these equations, the linear isoclines do not pass through the origin but generally intersect the hay axis. The fact that they are linear and do not pass through the origin means that if minimum feed costs are to be attained as the cow is taken to higher levels of milk output, the proportion of feeds should change. The intersection of the hay axis by the isoclines indicates (1) that hay alone might be fed at low milk levels and (2) that proportions of feed should change to include more grain as feeding levels are increased. Thus the general configuration of the isoclines appear logical, but as is pointed out later, those for equation 2a do not appear as acceptable as those for equation 1a.

Functions with time as a variable allow estimates of the rate of change in milk production as the lactation period progresses. Equations 1d and 2d, based respectively on equations 1a and 2a, are marginal time-yield equations. They indicate the decline in milk production associated with each unit progress of time beyond the beginning of the experimental period, and are used for estimates in a following section.

$$(1d)\quad \frac{dM}{dT} = -14.22 - 8.7584T - .1570G - .0865H$$

$$(2d)\quad \frac{dM}{dT} = -.000054H^2 - .000152G^2 - 2.0752T^2$$

For reasons that are made evident in the latter part of this report, equation 1a is used as the more logical estimate of the milk production function. However, certain estimates from equation 2a are included for readers who may wish to accept predictions only in terms of probability.

Production surfaces and isoquant schedules

Milk production surfaces derived from equation 1a are presented in Figure 1 for the first month, the mean month and the sixth month of the

experiment (i.e. T = 1, 3.5, and 6 respectively).[6] The surfaces tend to telescope as time progresses, denoting that a given level of feeding will produce less milk. The milk isoquants take on greater curvature for high milk levels, indicating that as feeding levels are increased (1) relatively smaller variations in feed combinations cause larger variations in the substitution rates and (2) smaller ranges of feed combinations allow a specified level of milk production. Similarly, as time progresses, the

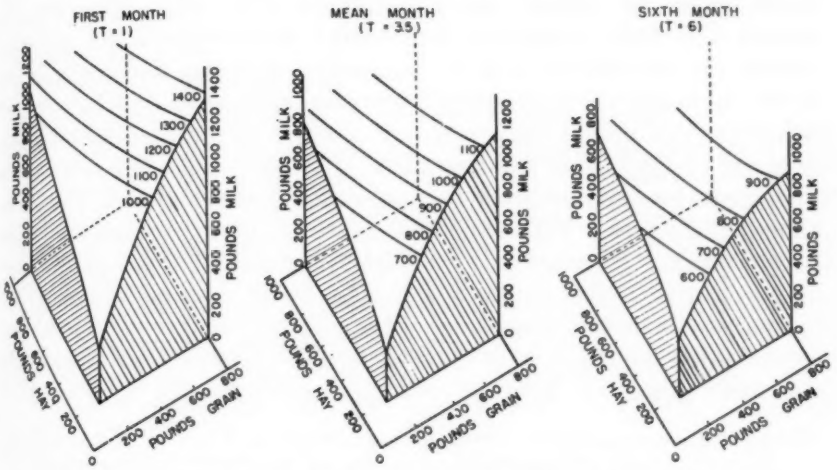

FIG. 1. PRODUCTION SURFACES ESTIMATED FROM EQUATION 1A FOR THE FIRST MONTH, MEAN MONTH, AND SIXTH MONTH OF THE EXPERIMENT, ABILITY SET AT MEAN OF 36 COWS.

milk isoquants tend to take on greater curvature, indicating a more rapid rate of change in substitution rates as feed proportions are varied in attaining a given milk level. Then, too, isoquants representing given increments in milk production increase in distance from the origin, over the surface, denoting decreasing marginal productivities of feed as the level of feeding a particular ration increases.

Feed quantities for producing stated milk production levels and marginal rates of substitution derived from equation 1a are presented in tables 2, 3, and 4 respectively for the first month, the mean month and the sixth month of the experimental period. For the predictions of the tables, increasing inputs of hay are required for higher milk levels, for a given grain level, because of diminishing productivity of feed. Also, the marginal rate of substitution of grain for hay increases (a) as the

[6] For the "mean" month, T has been set at 3.5, to include the last half of the third month and the first half of the fourth month.

ration includes a greater proportion of hay for given milk level and (b) as higher levels of milk are attained with greater hay inputs, grain remaining constant.

Within the range of rations presented, the marginal rates of substitution of grain for hay generally vary from 2.5 to 1.5. These substitution coefficients provide one relevant basis for nutritional and economic evaluation of feeds. If marginal rates of substitution are used in evaluation, the relative value of a particular feed varies as its proportion in the ration varies. In contrast, the conventional TDN (total digestible nutrients) and ENE (estimated net energy) standards used in nutrition assume the substitution rates to be constant and that the isoquants are linear. Nutritionists have agreed, however, that grain and hay do not substitute at constant rates over the entire milk surface. (Grain alone is never recommended and hay alone is seldom recommended; rations that might be optimum under an unrestricted assumption of linear isoclines.) Wide use of TDN and ENE transformations has been continued because of lack of other data in indicate the rate at which substitution ratios change. However, TDN and ENE ratios can be computed for comparison with the substitution rates in tables 2, 3, and 4. Based on feeds used in the study, a TDN evaluation of feeds gives a ratio of 1.350 (i.e. .6863 pound of TDN per pound of grain divided by .5065 TDN

TABLE 2. FEED COMBINATIONS IN PRODUCING SPECIFIED MILK LEVELS IN 28 DAYS, AND MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY BASED ON EQUATION 1A. ABILITY FIXED AT MEAN OF COWS IN EXPERIMENT. FIRST MONTH OF EXPERIMENTAL PERIOD (T=1)

Level of grain (pounds)	Pounds of hay required to maintain milk output of:[a]					Marginal rates of substitution ($\Delta H/\Delta G$); pounds hay replaced by one additional pound of grain along indicated milk isoquant.[b]				
	1,000 lbs.	1,100 lbs.	1,200 lbs.	1,300 lbs.	1,400 lbs.	1,000 lbs.	1,100 lbs.	1,200 lbs.	1,300 lbs.	1,400 lbs.
150	883	1,040				2.41	2.63			
200	766	913	1,093			2.29	2.46	2.77		
205	654	793	960			2.18	2.32	2.55		
300	547	680	837	1,037		2.09	2.20	2.38	2.76	
350	445	573	722	906		2.01	2.10	2.24	2.51	
400	346	470	613	785	1,024	1.94	2.01	2.13	2.33	2.87
450	250	371	509	673	889	1.87	1.93	2.02	2.18	2.54
500	158	276	410	567	768	1.81	1.86	1.93	2.06	2.31
550		185	315	467	657		1.79	1.85	1.95	2.14
600			225	372	554			1.78	1.85	2.00
650				282	457				1.76	1.87
700				196	366				1.08	1.76
750					280					1.67
800					199					1.57

[a] Predicted from equation 1b.
[b] Predicted from equation 1c.

TABLE 3. FEED COMBINATIONS IN PRODUCING SPECIFIED MILK LEVELS IN 28 DAYS, AND MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY BASED ON EQUATION 1A. ABILITY FIXED AT MEAN OF COWS IN EXPERIMENT. MEAN MONTH OF EXPERIMENTAL PERIOD

Level of grain (pounds)	Pounds hay required to maintain milk output of:[a]					Marginal rates of substitution ($\Delta H/\Delta G$); pounds hay replaced by one additional pound of grain along indicated milk isoquant.[b]				
	800 lbs.	900 lbs.	1,000 lbs.	1,100 lbs.	1,190 lbs.	800 lbs.	900 lbs.	1,000 lbs.	1,100 lbs.	1,190 lbs.
150	815	1,036				2.54	3.09			
200	692	891				2.37	2.74			
250	577	760	1,032			2.24	2.50	3.41		
300	468	640	877			2.12	2.32	2.85		
350	365	528	744			2.02	2.17	2.53		
400	266	423	623	973		1.93	2.05	2.31	4.00	
450	172	323	513	806		1.85	1.94	2.13	2.90	
500		229	410	674			1.85	1.99	2.45	
550		139	314	559			1.76	1.87	2.17	
600			223	455				1.76	1.97	
650			138	361				1.66	1.80	
700				275	716				1.66	4.79
750				194	575				1.53	2.09
800				122	486				1.41	1.53

[a] Predicted from equation 1b.
[b] Predicted from equation 1c.

TABLE 4. FEED COMBINATIONS IN PRODUCING SPECIFIED MILK LEVELS, AND MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY BASED ON EQUATION 1A. ABILITY FIXED AT MEAN OF COWS IN EXPERIMENT. SIXTH MONTH OF EXPERIMENTAL PERIOD.

Level of grain (pounds)	Pounds hay required to maintain milk output of:[a]				Marginal rates of substitution ($\Delta H/\Delta G$); pounds hay replaced by one additional pound grain along indicated milk isoquant[b]			
	600 lbs.	700 lbs.	800 lbs.	900 lbs.	600 lbs.	700 lbs.	800 lbs.	900 lbs.
150	564	801			2.40	2.98		
200	448	661			2.24	2.62		
250	339	537	867		2.11	2.38	3.88	
300	236	422	701		2.06	2.20	2.93	
350		316	566			2.06	2.50	
400		216	448			1.93	2.23	
450			341				2.04	
500			244	732			1.88	4.76
550				530				2.67
600				414				2.06
650				320				1.71
700				242				1.44
750				176				1.18

[a] Predicted from equation 1b.
[b] Predicted from equation 1c.

per pound of hay); an ENE evaluation of feeds gives a ratio of 1.788 (i.e. .7404 therms per pound of grain divided by .0100 therms per pound of hay). Interpreted strictly, the first ratio means that 1 pound of grain has as much feeding value as 1.350 of hay; the second ratio suggests that 1 pound of grain has as much feeding value as 1.788 pounds of hay.

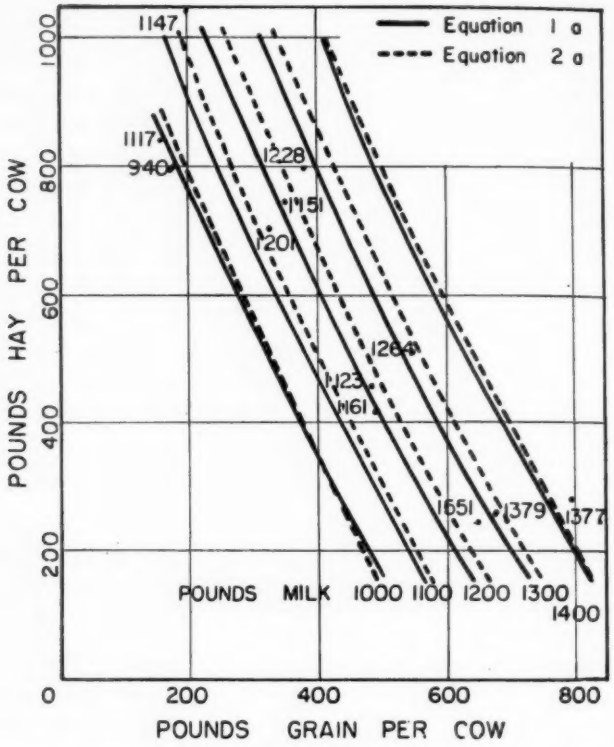

FIG. 2. MILK ISOQUANTS FOR THE FIRST MONTH OF THE EXPERIMENT, BASED ON EQUATIONS 1A AND 2A. ABILITY FIXED AT MEAN FOR 36 COWS. (Dots show feed quantities which produced stated milk levels in pounds from cows of medium ability.)

The ENE value falls within the range of substitution ratios of tables 2, 3 and 4, but generally at the level of substitution rates for rations including a large proportion of grain. Few marginal rates of substitution of grain for hay can be found in the tables that are as low as the 1.350 TDN ratio of feeds. These differences may result because TDN and ENE evaluations ordinarily are based on experiments with animals receiving a high ratio of grain in the ration (as well as because of sampling variations in this and other studies). On the basis of the data presented, the ENE basis of evaluating feeds appears more nearly consistent with the

predictions of this study. Any feed evaluation standard that assumes constant transformation ratios is not strictly accurate, of course, if the production function is not linear with straight-line isoquants. Further research that firmly established marginal rates of feed substitution will provide an improved basis for feed evaluation. Obviously, feed evaluations that correctly express either (1) the amount of product that the nation can obtain from its feed and land resources or (2) the costs and

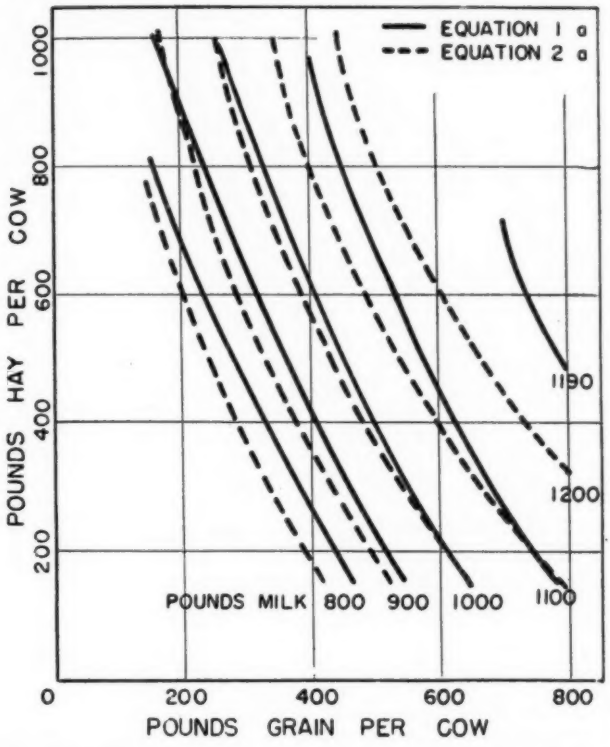

FIG. 3. MILK ISOQUANTS FOR MEAN MONTH OF EXPERIMENT, BASED ON EQUATIONS 11A AND 22A. ABILITY FIXED AT MEAN FOR 36 COWS.

returns that farmers can realize from their capital can be based on marginal rates of substitution such as those predicted in this study.

Figures 2, 3, and 4 provide graphs of milk isoquants for the first month, the mean month and the sixth month of the experimental period, based on equations 1b and 2b. Since the slopes of the isoquants are similar, estimates of the feed substitution rates based on equations 1c and 2c do not differ significantly, in the first month of the experiment. Evaluation of feeds or rations based on the marginal rates of substitution would generally result in the same conclusion for the first month.

Differences would be unimportant in the mean month for low levels of milk production, with only slight differences for high levels. In the sixth month, however, the greater curvature of isoquants predicted from equation 2c would lead to quite different ration recommendations, for particular feed price ratios, than those based on equation 1a.

Since most of the isoquants have relatively small curvature and since

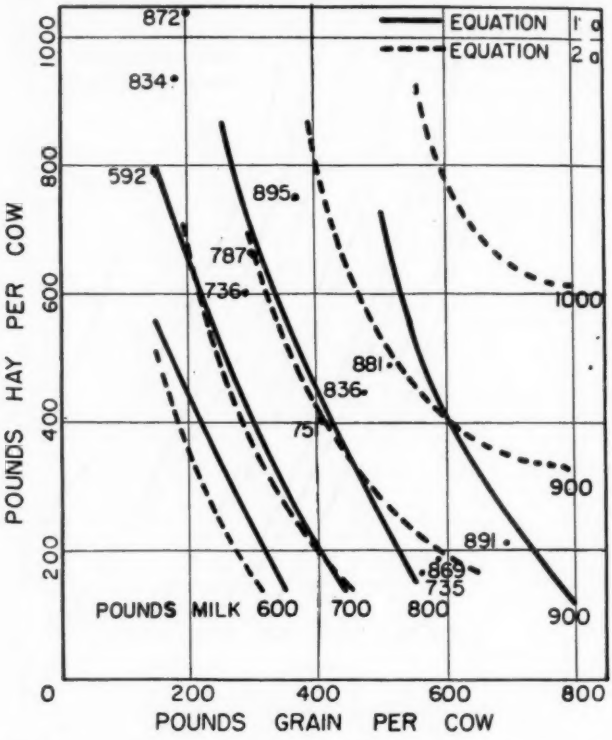

FIG. 4. MILK ISOQUANTS FOR SIXTH MONTH OF EXPERIMENT, BASED ON EQUATIONS 11A AND 22A. ABILITY FIXED AT MEAN FOR 36 COWS. (Dots show feed quantities which produced stated milk level in pounds from cows at medium level of ability.)

their slope does not differ greatly from a line expressing normal price ratios, the following economic interpretation results: Feeding at the upper end of the isoquants, with a relatively large proportion of hay to grain, does not cause great profit sacrifices even in cases where price ratios would specify points or rations lower on the milk contour. In other words, feeding hay at or near stomach capacity would not lower profits materially and might increase them when self-feeding of hay saves considerable labor costs.

The milk contours in the figures 2, 3 and 4 take on greater curvature

for higher milk levels, for both equations 1a and 2a, indicating that as feeding levels become greater, relatively small variations in feed combinations tend to cause larger variations in the substitution rates. Similarly as time progresses (i.e. from Figure 2 to Figure 3 to Figure 4), the milk isoquants tend to take on greater curvature, indicating a more

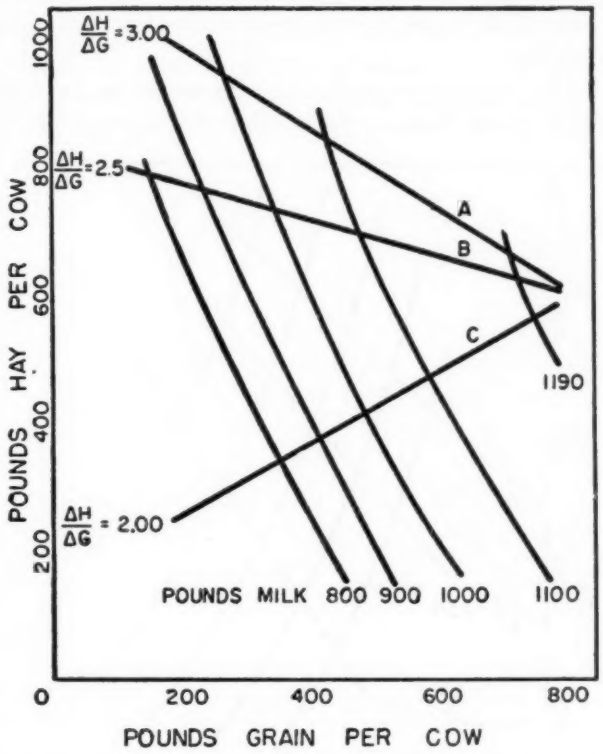

FIG. 5. ISOQUANTS AND ISOCLINES FOR MEAN MONTH OF EXPERIMENT AND FOR GIVEN SUBSTITUTION RATES, ESTIMATED FROM EQUATION 1A. ABILITY AT MEAN FOR 36 COWS.

rapid change in substitution rates as feed proportions are varied in attaining a particular milk level. The relatively "flat" isoquants for low milk levels and early points in time were expected. An alternative hypothesis about the nature of the isoquants but not shown by these equations is that they are nearly linear in the middle, with sharp curvature or "hooks" near the stomach and physiological limit lines.

Isoclines

Isoclines, along with milk isoquants, are presented in Figure 5 for milk function 1a and in Figure 6 for function 2a. These isoclines trace

out the path of feed combinations that result in a given substitution rate between hay and grain, as milk is taken to higher levels (i.e., is denoted by isoquants higher in the feed plane). In other words, 1 pound of grain substitutes for 3.00 pounds of hay for the feed combinations traced out by isocline A. If the grain/hay price ratio were also 3.00, isocline A traces the least-cost combination of feeds for the various milk levels. Similarly, isocline C traces out the least-cost ration when the grain/hay price ratio is 2.00.

Although the regression coefficients for equation 2a have relatively lower standard errors than do the coefficients for equation 1a, the slopes

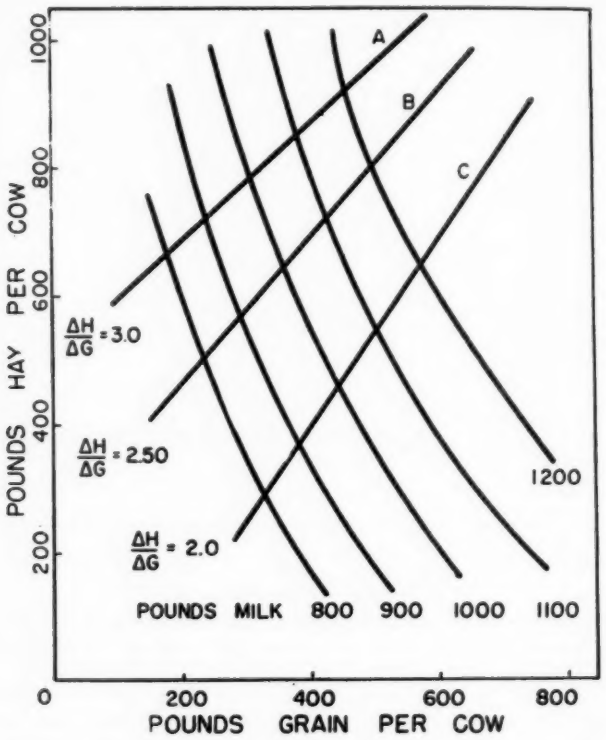

FIG. 6. ISOQUANTS AND ISOCLINES FOR MEAN MONTH OF EXPERIMENTAL PERIOD, AND GIVEN SUBSTITUTION RATES, ESTIMATED FROM EQUATION 2A. ABILITY AT MEAN FOR 36 COWS.

of the isoclines in Figure 5 appear more in line with physiological characteristics of milk production than those in Figure 6. They converge more rapidly, suggesting a maximum possible level of milk production. (The point at which the isoclines converge defines the single ration consistent with maximum milk production per cow.) Convergence and defi-

nition of a maximum milk level is not so apparent in Figure 6 for equation 2a. For all isoclines shown in Figure 6, a greater absolute amount of hay would be fed as price ratios favor higher levels of milk output. Perhaps more realistically, the upper isoclines in Figure 5 suggest a smaller total amount of hay as milk output is taken to higher levels. The slope of isoclines A and B in Figure 5 are consistent with the notion of a stomach-limit line, specifying that if cows are on a high hay ration, milk output can be increased only by reducing total hay inputs and increasing total grain inputs. Even for the isoclines of Figure 6, however, the proportion of hay would decline if the level of feeding were increased to maintain a given substitution ratio (i.e. to keep the substitution equal

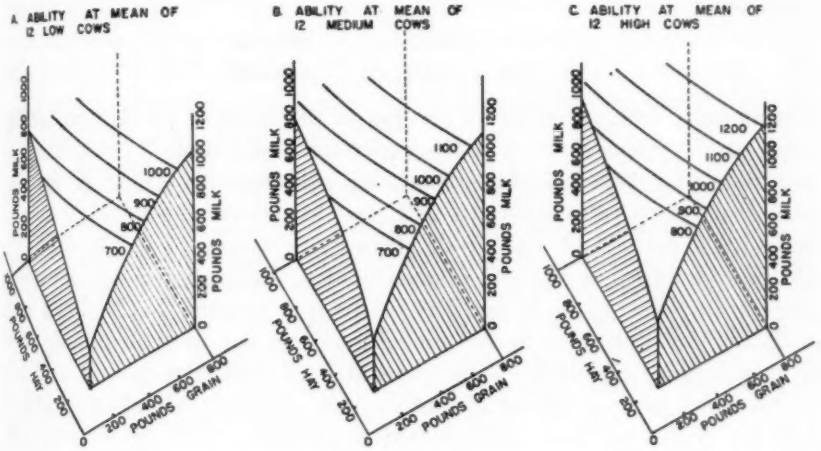

FIG. 7. MILK PRODUCTION SURFACES PREDICTED FROM EQUATION 1A FOR COWS AT THREE LEVELS OF ABILITY. TIME (T) IN THE EQUATION IS SET AT THE MEAN.

to the price ratio). This is true since the isoclines intersect the hay axis. Higher levels of feeding specify more of both hay and grain, but the proportion of hay declines because the initial input of grain is zero.

Figure 7 provides production surfaces estimated from equation 1a, with cow ability fixed at three different levels and with time fixed at the mean month. The slopes of these surfaces are the same; the only difference being the height of milk levels at which the surface slopes begin. In other words, the entire surface is moved upward as the level of ability increases, because ability is included as a linear term only in the equation employed.[7] However, the rates of hay/grain substitution

[7] Statistical analysis not included in this paper indicated a linear relationship for ability. Hence, non-linear terms were not included in equations 1 and 2.

differ among ability levels for a given milk level. This is true because a milk contour, such as 1,000 pounds, falls lower on the sloping portion of the surface as the level of ability increases. As is illustrated in figures 2, 3 and 4, the curvature of the isoquants (i.e., the marginal rates of substitution) changes for milk contours spaced further over the feed plane.

Specification of Economic Optimum in Rations

Prediction of the milk production function or surface allows specification of the ration that will maximize returns above feed costs. By setting the derivative of hay in respect to grain, equation 1c, to equal the price ratio, as in equation 1e, the least-cost ration for any milk level can be predicted.

$$(1e) \qquad -\frac{2.9740 - .002384G - .001056H}{1.5437 - .000776H - .001056G} = \frac{P_g}{P_h}$$

In this case, with equation 1a serving as the basis of prediction, ability is set at the mean of cows in the experiment and time is set at the first month of the experimental period. By reference to Table 2, for any grain/hay price ratio equal to 2.01, the least-cost combination to produce 1,000 pounds of milk in 28 days (with a cow of mean ability) is 350 pounds of grain and 445 pounds of hay. This ration is the least-cost one for any level of grain and hay prices (per pound) that yields a ratio of 2.01. (The statement makes no reference to the most profitable level of production.) Similarly, with grain at 1.93 cents per pound and hay at .80 cents per pound (or any other pair of prices yielding a ratio of 2.41 the least-cost feed combination to produce 1,000 pounds of milk under previously stated conditions of time and ability is 150 pounds grain and 883 pounds hay in the 28 days (5.4 pounds grain and 31.5 pounds hay per day). The substitution rates in tables such as 2, 3 and 4 allow prediction of least-cost rations for particular milk levels in any month of the experiment (months 3 to 8 of the lactation). For example, when the price of grain is 2.45 cents per pound and the price of hay is 1.0 cents per pound, the grain/hay price ratio is 2.45. In Table 3, when the marginal rate of substitution of grain for hay, $\Delta H/\Delta G$, is 2.45, the minimum-cost feed combination to produce 1,100 pounds milk in the mean month of the experiment with a cow of mean ability is 500 pounds grain and 674 pounds hay.

Increases in costs or sacrifices in profit are not great for small deviations away from the feed combinations where the substitution rate is equal to the price ratio. In the cases above, for example, the cost of the optimum ration for 1,100 pounds of milk is $18.99. If a ration of 600 pounds of grain and 455 pounds of hay were used, the feed cost would

be \$19.25; for 800 pounds of grain and 122 pounds of hay, the feed cost would be \$20.82. These differences in feed costs are perhaps not great enough to offset the added labor costs for feeding particular hay rations. When labor costs are figured, the least-cost milk production may be attained when the optimum level of grain feeding is determined in relation to the grain/milk price ratio, with self-feeding of hay to stomach capacity.

The gain from feeding one ration, rather than others along a milk contour, increases with greater curvature of the isoquant. Also, since the slopes of the milk isoquants tend to increase with level of milk production, gains in feeding the unique optimum ration are greater as the level of milk production increases (i.e. the grain/milk price ratio decreases). As time in the lactation period increases (although the gains from feeding unique rations are relatively low from the predictions of this study) the final advantages of particular rations for given milk levels can be determined only as the nature of the milk surface and its isoquant family are more accurately established.

Simultaneous Specification of Ration and Milk Levels

Equation 1a now can be used to compute the partial derivatives for specification of both the optimum ration and the optimum level of feeding. In equation 1f below, the partial derivative for grain is equated to the grain/milk price ratio when milk is 4.00 cents per pound and grain is 3.00 cents per pound, in the first month for a cow of mean ability. In equation 1g, the partial derivative for hay is equated to the hay/milk price ratio when hay is 1.25 cents per pound.

$$\frac{\partial M}{\partial G} = 2.5815 - .002384G - .001056H = \frac{\$3.00}{\$4.00} \tag{1f}$$

$$\frac{\partial M}{\partial H} = 1.3275 - .000776H - .001056G = \frac{\$1.25}{\$4.00} \tag{1g}$$

By simultaneous solution of equations 1f and 1g, the prediction is that the ration that maximizes return above feed costs should include 799 pounds of hay and 579 pounds of grain fed over 28 days (28.5 pounds of hay and 20.7 pounds of grain per day) to produce 1,479 pounds of milk, and a return of \$31.80 above feed costs. If a radically different ration such as 275 pounds of hay and 707 pounds grain had been fed under these price relationships, the return above feed costs is estimated at \$29.63. With feeds remaining at these prices and milk increasing to 5.00 cents, the optimum ration includes 786 pounds of hay and 648 pounds of grain, with milk production at 1,522 pounds. With milk falling to 3.00 cents, the optimum ration includes 820 pounds of hay and

TABLE 5. ESTIMATED OPTIMUM FEED QUANTITIES AND MILK PRODUCTION IN THE FIRST MONTH, MEAN MONTH, AND SIXTH MONTH OF EXPERIMENTAL PERIOD, FOR VARIOUS PRICE RATIOS. ESTIMATES FROM EQUATION 1F AND 1G WITH ABILITY AT MEAN.[a]

Feed Prices			Milk Prices Per Cwt.								
Grain per cwt.	Hay per ton	Price ratio:[b] grain / hay	$3.00			$4.00			$5.00		
			Hay, grain and milk quantities (pounds)								
			Hay	Grain	Milk	Hay	Grain	Milk	Hay	Grain	Milk
Month 1											
$2.00	$15.00	2.67	882	577	1501	846	663	1544	843	715	1563
3.00	15.00	4.00	1361	225	1328	1204	400	1446	1110	504	1500
3.00	25.00	2.40	820	465	1387	799	579	1479	786	648	1532
3.00	35.00	1.71	275	707	1357	390	761	1462	458	793	1511
4.00	35.00	2.29	762	350	1224	756	493	1388	752	579	1464
Mean Month											
2.00	15.00	2.67	745	473	1100	710	560	1143	686	612	1163
3.00	15.00	4.00	1223	121	926	1066	296	1045	972	400	1100
3.00	25.00	2.40	682	361	986	662	476	1080	649	544	1121
3.00	35.00	1.71	—[c]	503	—	252	657	1062	322	690	1111
4.00	35.00	2.29	624	247	824	618	390	988	613	476	1064
Month 6											
2.00	15.00	2.67	608	369	825	570	456	867	548	508	887
3.00	15.00	4.00	1085	18	651	928	193	770	834	297	884
3.00	25.00	2.40	545	257	710	524	372	803	511	440	845
3.00	35.00	1.71	—[c]	499	—	—[c]	553	785	184	586	835
4.00	35.00	2.29	486	144	549	480	286	712	475	372	787

[a] Figures show the most profitable ration and milk level for each combination of hay, grain and milk prices. For example, with hay at $25.00, grain at $3.00 and milk at $3.00 the most profitable ration includes 465 pounds of grain, 820 pounds of hay and produces 1387 pounds of milk in the first month.
[b] Price per pound of grain divided by price per pound of hay.
[c] Physiological minimum hay quantity.

465 pounds of grain, with milk production at 1,387 pounds. If milk remains at 4.00 cents and hay increases to 1.75 cents, an increase in grain price to 4.00 cents per pound has the following effect on the optimum ration: The feed combination should include 756 pounds of hay and 493 pounds of grain, to produce 1,388 pounds of milk in the first month from a cow of medium ability. With these same prices in the sixth month, the ration would include only 480 pounds of hay and 286 pounds of grain, producing as estimated 712 pounds of milk.

It is of interest to compare the optimum rations indicated in Table 5 with those based on Jensen, et al.[8] Predictions based on the Jensen study would indicate that for prices of $1.25, $3.00 and $4.00 per cwt. respectively for hay, grain and milk, the optimum ration would include: 350 pounds of grain and 800 to 900 pounds of hay for a good cow producing 40 pounds of milk per day (1,120 pounds in 28 days). Estimates for the same prices based on equation 1a of this study indicate 476 pounds of grain and 662 pounds of hay to produce 1,082 pounds of milk, for a cow of mean ability in the mean month of the experimental period. With prices of $35.00 per ton for hay, $4.00 for grain, and $5.00 for milk, the estimates based on the Jensen study include about 330 pounds of grain,

[8] Einar Jensen, et al. *Input-Output Relationships in Milk Production*, U.S.D.A. Technical Bulletin 815. 1942.

and a residual of 800 to 900 pounds of hay. The estimates of the current study include 476 pounds of grain and 613 pounds of hay to produce 1,064 pounds of milk in 28 days.

Contributing Information

The data provided in this study are of a methodological nature. The writers feel that they should serve as a foundation upon which other studies can be based. Although they do not provide "final answers" to the nature of the milk production function, they do begin to fill a void in basic knowledge that has prevailed for many decades. Important contributions can be made to this gap in knowledge with somewhat fewer resources than was previously thought necessary. As additional information of the nature outlined is made available, answers can be more nearly given to the effectiveness of acreage shifts and production control on farm output, to the optimum crop patterns for conservation farming, to general questions of economy in dairy production, and to basic questions in animal nutrition. Although the data presented may not bring about any great revolution in feeding methods, they do help improve basic scientific knowledge. For several decades nutritional research has been carried on to provide feeding standards and methods of feed evaluation. Much research currently is under way to accomplish this same end. The framework provided in this experiment is the more correct one for the scientific phenomena concerned. By extension of the general method greater knowledge of basic relationships can be provided from given research resources. The authors recognize the main limitations of the study; namely, a relatively small number of observations, use of a single grade and kind of forage, some lack in extremes of rations and first month outputs which are not unrelated to weight losses. However, these stem mainly from restricted resources and might be overcome by a more elaborate experiment.

THE AVERAGE AND MARGINAL PRODUCT OF FARM LABOR IN UNDERDEVELOPED ECONOMIES

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Introduction

REDUCING underemployment of labor in the agricultural sector of the economy is generally regarded as one of the most fruitful approaches to the amelioration of the low-income problem in underdeveloped areas of the world. Knowledge of the schedule of marginal productivity of labor in agriculture, and particularly of the regional variation in that schedule, is of critical importance in making decisions concerning the desirability of developing additional employment opportunities, in choosing the form such employment opportunities might best take, and in planning the location of such opportunities once decided upon. In this paper, we suggest a modification of the traditional model in labor productivity theory, test a portion of the hypothesis presented against certain empirical data and draw some implications of practical significance from the model and data presented.

Hypothesis

The hypothesis presented is that in underdeveloped economies a tendency exists or has recently existed towards an equalization among farms and areas of the average product rather than the marginal product of agricultural labor. If the average product of labor tends to be equal on various qualities of land, then as production functions vary the marginal product of labor will tend to vary.

We see the likelihood that in some situations the marginal product of labor may be very small, considerably less than the amount required to provide subsistence for the marginal elements of the labor force. In fact it may be zero in some cases. In other situations, the marginal product of labor may be positive and as large as required to provide subsistence for the marginal elements of the labor force. Very small marginal products will tend to be the situation on soils that produce a large total product per unit of land. Larger marginal products of labor will tend to hold on soils that produce a small total product per unit of land.

Graphic Illustration

If the total product curves rises steeply with early inputs of labor, carrying average product well above the subsistence level, scope is provided for

* Several members of various departments at Cornell University were extremely helpful to the authors. The authors appreciate the time, criticism and new ideas contributed.

a concentrated population or population growth, thereby allowing net additions to population and thereby increasing the labor input (Figure 1). For example, with labor input *a* the average product curve reaches a maximum well above the subsistence level. This encourages population increase. As the population increases more labor will become available for farm work. At first, the increments in labor will provide a positive marginal product that is also higher than the subsistence level. When point *b* is reached by increasing labor input, the marginal product will have dropped to the subsistence level. At this point, the last increment to the labor force is able to supply just enough additional product to fully provide for its own support at the subsistence level. At this point (*b*), the average product is still well above the subsistence level. Therefore population, and hence labor input, can continue to increase. At point *c* the marginal product has reached zero, and yet the average product is still higher than the subsistence level, providing scope for continued population increase. With marginal product remaining at zero, it is only when point *x* is reached that average product finally drops to the subsistence level. At this point, further net increments of population will not occur, at least as averaged over a period of years, and a point of balance will have been reached between food and population.[1]

None of the additional labor inputs from *c* to *x* have contributed additional product toward their own support and at no point from *b* to *x*

[1] Insofar as the farms under consideration are owner operated farms, the model as presented seems valid without modification. Modification might be in order if the farms are rented. The more normal pattern of rental in underdeveloped areas of the world is one of share rentals. (United Nations, *Land Reform, Defects in Agrarian Structure as Obstacles to Economic Development*, 1951.) In the case of share rentals the analysis presented would apply in its essentials, since in this case all the curves would simply be reduced by a given percentage at each point. The quantity of labor input providing no added product would be smaller, but the possibility of the marginal product declining to zero would still remain on the very productive soils.

The model is not appropriate if farms are rented for a fixed rent and landlords exercise their bargaining powers to the fullest. In this situation the economics of the question indicate that rents would tend to rise to the point of equaling the area *d e f g* (Figure 1), which would require that the product of the marginal worker be equal to his subsistence requirements. In this case marginal products would be equal on different kinds of land and the analysis we apply in developed economies concerning marginal productivity would suffice. Then, purely from the viewpoint of considerations of marginal productivity, it would be just as desirable to pull labor for nonfarm employment from one kind of land as another. However, the model still has a fair degree of applicability in cases of fixed rents if the landlords do not receive all the rent theoretically possible. The relatively more static or "sticky" nature of rents as compared with other cost and return elements tends to provide a basis for this at least during certain periods. (See for example Kamol O. Janlekha, *A Study of the Economy of a Rice Growing Village in Central Thailand*, unpublished Ph.D. thesis, Cornell University, 1955, page 140 *et seq.*). The effect of land taxes may be analyzed similarly.

has an increment of labor produced a sufficient increment in product to provide fully for its own subsistence. These last increments to the labor force have had to depend for subsistence upon the surplus product (that above subsistence needs) of prior increments to the labor force. Under such conditions there is clear scope for increasing total production through introduction of other production possibilities that would use this surplus labor.

A contrasting situation is depicted in Figure 2. Here the average product curve, at its peak, just reaches the subsistence line. At this point average product and marginal product are equal. Thus the mar-

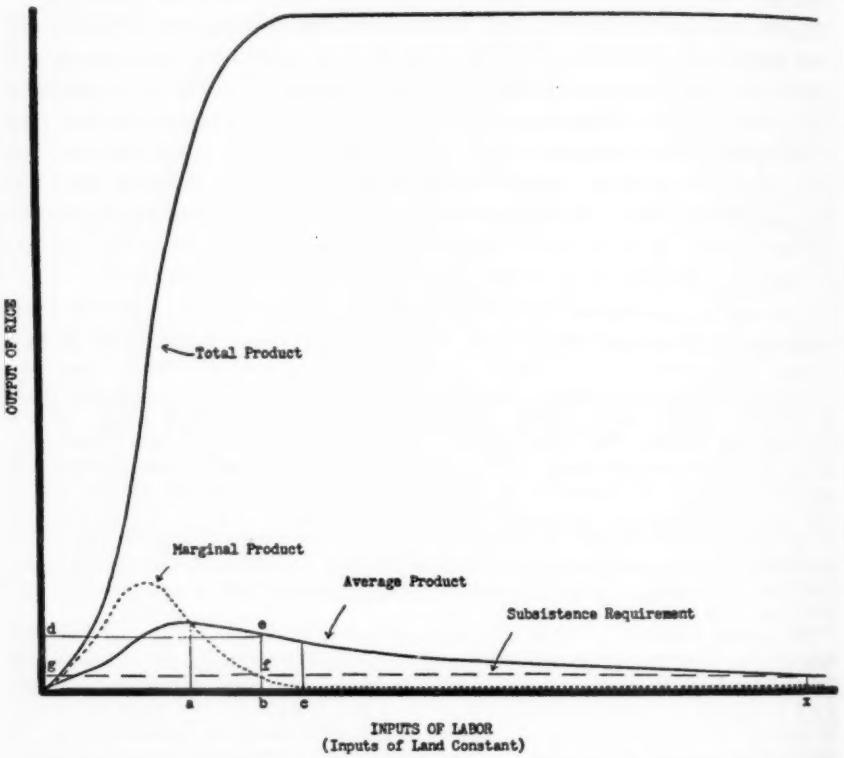

FIG. 1. HYPOTHETICAL LABOR PRODUCTION FUNCTION, HIGHLY PRODUCTIVE SOILS

ginal product is also at the subsistence level. Beyond point *y*, further additions to the labor force will provide a production increment that is less than the subsistence requirement and will also tend to pull the average product curve below the subsistence level. Such additions would clearly represent an unstable situation. The stable position is in this case at input point *y*, the peak of the average product curve.

The situations depicted in Figures 1 and 2 represent extremes. The first represents the situation for highly productive soils, such as rich alluvial and delta soils. The second situation represents the relatively unproductive soils of hilly and dry areas.[2] Ranged between these extremes would be soils of varying productivity. In general, the more productive is the soil the more labor one may expect to find beyond the point at which the marginal product of labor is equal to the subsistence level.

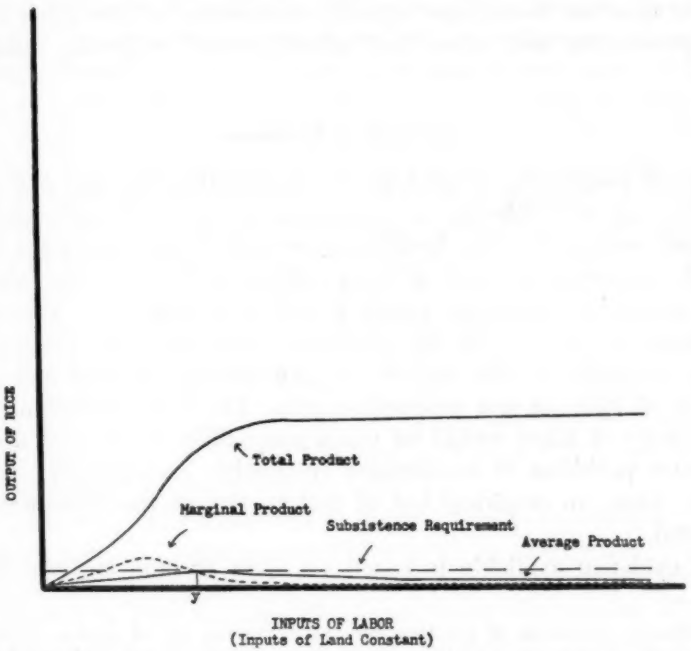

FIG. 2. HYPOTHETICAL LABOR PRODUCTION FUNCTION, LOW PRODUCTIVITY SOILS

It is thus the "highly productive" soil associations on which we should expect to find a sizeable labor supply which presently produces little or no product.

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[2] The basic phenomenon discussed is of course influenced by the slope of the total product curve as well as its maximum height. Thus it is theoretically possible for land that provides a high yield per acre to use a large input of labor, providing a high density of farm population and yet have an average product per worker that never climbs much above subsistence and thus provides no scope for marginal product to drop much below the subsistence level. The authors' conclusion is that this shape of yield function for labor input is not frequently encountered so that the generalization of low marginal productivity of labor on highly productive soils and high marginal productivity of labor on relatively unproductive soils will be found tenable in most specific cases.

In the developed economies we usually depict the "poor soil" situations as not only the areas of marginal land but also as supporting the marginal members of the agricultural labor force, from which future additions to the industrial labor force should be drawn. In the model depicted here, the poor soil situations would not be the logical sources of such labor until sufficient labor had been drawn from the rich soil areas to cause operation at a point at which the marginal product of labor was at a point at least slightly in excess of the subsistence level.[3] Only at this time would one logically commence to draw labor from the least productive soil areas—land abandonment occurring during this stage.

Empirical Evidence

Data of reasonable adaptability for calculating the marginal product of labor are available for a productive, alluvial soil association in a Thailand community. The hypothesis presented suggests that in such an area the marginal product of labor will be well below the subsistence level, somewhere between points b and x in Figure 1, although not necessarily to point x at this particular point in time. No data were readily available to the authors for calculating marginal and average product of labor in less productive areas. The task of determining the productivity of labor would be much more difficult for such areas due to greater problems of maintaining reasonable homogeneity within the sample. Thus, an empirical test of that portion of the hypothesis is not presented.

The evidence available is based on labor income records, obtained

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[3] Production functions of the type we are discussing are of course developed on the assumption of constant technology. Shifts in the schedules might well occur as a result of the introduction of new technology, thus causing, at least in the short run, even the marginal productivity of labor to become positive in situations in which it is presently zero over a considerable range of real data. It cannot, of course, be known precisely what changes in the shapes of these production functions future technological innovations will cause. Technological innovations such as improved fertilizers, seeds, etc, may shift the function sufficiently to provide a positive marginal product for an additional quantity of labor. Such innovations are more apt to provide such a shift in the schedules in underdeveloped areas than in the developed areas of the world. In highly mechanized agricultures much machinery is operating at less than its power capacity. Extra harvesting and similar operations can be carried on at the same surface speed even though the work performed in a given area has changed substantially. In contrast, in areas using primarily hand labor this underuse of power capacity does not generally exist at least to the same degree. Thus labor-saving machinery would shift the schedules to the left, thereby increasing the quantity of agricultural labor with very low marginal productivity. Mechanization tends to be more advantageous to the "better" soil areas, thus widening the differences in the schedules depicting the marginal productivity of labor.

by personal interview from rice farms at Bang Chan, Thailand.[4] This agricultural village is located in the Central Plain, 20 miles northeast of Bangkok. A judgement sample of 104 farms was chosen that is believed to be representative of all the farms in Bang Chan village. The sample includes 45 percent of the village farms. The farms ranged in size from four rai (1.6 acres) to 110 rai (43.4 acres) and from 1 to 11 man equivalents of available labor, hired and family labor included. The means are respectively, 33.8 rai (13.6 acres) and 3.4 man equivalents.

The village is on flat, alluvial soil, generally uniform in production potential. Thus, for the following analysis, quantitative measures of land were assumed to reflect adequately changes in land input. The small amount of production capital employed in rice farming in Bang Chan consists of plowing animals and hand implements used by the laborers. The timing of production processes, the tools used and all aspects of rice culture are traditional and standardized. It therefore seems realistic to assume that all farms have a similar rice production function, and that relevant production functions may be derived from an array of production information from the individual farms.

Yields were measured in tang per rai. One tang equals approximately 24 pounds or .54 bushels and one rai equals approximately .4 acres. Yields were determined from total farm output and land area operated. Total farm output of rice is known because most of the rice is taken to the local miller to be polished. The land area each family operated was found to be known accurately by the farmers.

Input of labor was measured in terms of man equivalents. A man equivalent equals 12 months of available time for farm work by an adult capable of performing farm work. Man equivalents were determined from answers to interview questions concerning the number of persons available for farm work on each farm. All persons 15 years of age or older were considered adults in this determination. Children under 15, and those unavailable for farm work were excluded. Thus, in this analysis, labor that is available for farm work but is doing no work is counted as part of labor input. Labor that is actually on the field but contributing no increment in output through its efforts is not treated differently from labor that is not working but is available for such work. In many areas all labor that is lacking alternative opportunities is in use at the seasonal peak of labor requirements. Those with a large labor input per unit of land then finish the job sooner than those with a small labor input. If those farms that use a smaller labor input do not have significantly

[4] The authors wish to thank Kamol O. Janlekha for his assistance in obtaining data from records secured by him for the Cornell-Thailand Project of the Department of Sociology and Anthropology, Cornell University, and that Department for permitting use of these records.

reduced yields, then the additional laborers on farms with a greater labor input are producing little or no additional product. As used here the concept of labor input is more nearly a concept of a stock of labor

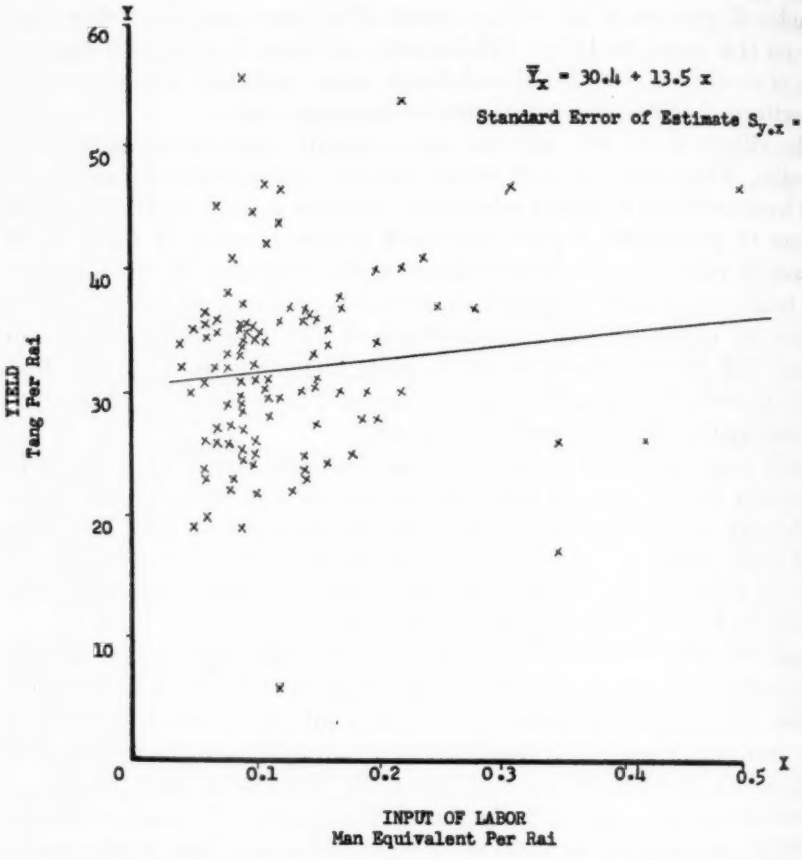

FIG. 3. RELATIONSHIP OF YIELD OF RICE TO LABOR INPUT (104 Rice Farms, Bang Chan, Thailand, 1948)

than a flow of labor. For the reasons elaborated above, this seems to be the most useful labor concept.

To estimate the productivity of labor, a least squares linear regression equation was computed with yield as the dependent variable.[5] Figure 3 presents a scatter diagram of the 104 farms with the calculated regression

[5] The spread of the data suggests that there is little justification for fitting other than a linear regression line. Also, since the data cover a relatively short segment of the production function and may well be on a part of the total curve that is nearly flat, economic logic also suggests the use of a linear regression line.

line plotted. The equation for this line is $Y = 30.4 + 13.5X$ (Y = total product, X = man equivalent). [Standard error of estimate, $S_{y.x} = 7.6$. Standard error for b, $S_b = 9.68$. Coefficient of variation = 23.7 percent at $x = .13$ (the mean of X)]. The b value (slope) in the equation, of 13.5 tang, is not significantly different from zero at the five percent level of significance. This is consistent with the hypothesis that in this type of an area, the marginal product of labor will be zero or close to zero.

In order to determine where these data fit on a labor production function such as that presented in Figure 1, an estimate of nutritional subsistence requirements is made. A recommended dietary allowance of 2,500 calories for a 25-year-old Bang Chan man has been computed by Hauck.[6] To provide a person with 2,500 calories per day for a year in the form of milled rice requires 35.4 tang of paddy (unmilled) rice. This amount of paddy rice is considered equal to the yearly minimum nutritional requirement for a consumption unit (one person 15 years or older or two persons under 15). Based on other Bang Chan farm data, which have a slightly different basis of measurement than the data previously cited, there are 5.0 consuming units per family. The average is 3.8 adults per family, four fifths of whom are available for farm labor. To produce enough rice paddy for the subsistence of the family, each available man equivalent of labor must produce 59.0 tang. Even this subsistence level that includes no provision for seed, other costs and nonfood elements of subsistence is nearly four and one-half times the calculated marginal product per man equivalent of labor (13.5 tang). The production of rice per consumption unit in Bang Chan is 218 tang—6.2 times the nutritional subsistence requirement of 35.4 tang. Production per consumption unit would clearly be a smaller multiple of full subsistence requirements, net of production costs, including minimal nonfood items and various other culturally defined elements. Production per consumption unit would only be as low as the full subsistence requirement if the whole village were close to an extreme Malthusian condition. These data for Bang Chan suggest that many families are living considerably higher than the full subsistence level while the marginal product for labor is substantially less than subsistence. Thus, it appears that on the average the farms in Bang Chan are operating just to the left of point c on the

[6] Hazel M. Hauck. Unpublished data. The recommended dietary allowance was based on an individual engaged in active work, adjusted for body size and climate in accordance with recommendations in FAO Nutritional Studies no. 5, "Calorie Requirements," FAO, Washington, D.C., June, 1950. The minimum nutritional subsistence requirement for a consumption unit based on a 25-year-old man provides a generous estimate. For at that age about maximum calorie allowances are made and also this estimate is applied to women who have a smaller body size. More than balancing this, however, is the obvious fact that calorie requirements omit other subsistence requirements such as clothing.

hypothetical labor productivity schedule in Figure 1. This evidence is fully consistent with the hypothesis presented.

Inferences and Conclusions

The hypotheses and data presented provide support for location of industry in underdeveloped areas so as to facilitate drawing the labor supply first from the rich, productive soil association areas of the nation rather than from poor soil situations. Clearly, decisions concerning the location of new industry must be made in the light of a great many criteria, not solely on the basis of the present location and the marginal product of certain units of the existing labor supply. By these particular criteria, however, the suggested location is consistent with that indicated by several other important criteria. The rich soil areas would tend to be the areas of dense population concentration, containing a relatively large labor supply within a given geographic area, thus shortening the commuting distance for a given supply of labor. They are also the areas of concentrated, potential local markets. In addition, they will tend to be the areas already more adequately serviced with transportation and communication lines.

From the Bang Chan data it is possible to estimate the quantity of labor in such a rich soil area that might be improved in economic position by a shift to local nonfarm employment. We can make some arbitrary assumptions about the number of laborers whose economic position might be improved by a real wage slightly in excess of the money equivalent of the low, calculated marginal product. We shall assume that in actual fact the marginal product per man equivalent was greater than the 13.5 tang, indicated by the regression line, for inputs up to .08 man equivalent per rai (1 man equivalent per 12.5 rai), and that after this point the marginal product was that indicated by the regression line (13.5 tang), or lower. Although this is an arbitrary choice, it seems conservative as there were 30 farms operating at this or less than this labor input per rai without an appreciably lower yield. Actually, in light of the data presented, it would not be unreasonable to assume that the marginal product of labor was zero within nearly the whole range of the data.

In the following calculation, the additional assumption was made that a man equivalent would be available from an individual farm for nonfarm work only after a full man equivalent had been reserved for every 12.5 rai or fraction thereof on each farm (.08 man equivalents per rai). Thus, fractions of a man equivalent were not counted as available for nonfarm employment. Likewise, of course, seasonally employed labor is not counted as available for nonfarm employment. On the basis of

these very conservative assumptions there were 53 man equivalents of labor available for nonfarm work—that is 15 percent of the total labor force.[7] The assumptions for calculating the amount of labor available for nonfarm work appear to be conservative, so underemployment is probably even greater.

Under these assumptions, and assuming the same density of population in nearby villages, the inference is that within a five-mile radius there is a labor force of 1,892 man equivalents currently on farms for which an annual wage at the money equivalent of slightly more than 13.5 tang of rice (i.e., a small fraction of subsistence requirements) would represent an improvement in the economic position of their family. Since it is likely that much of the underemployment of labor in underdeveloped economies is disguised, this method of estimating underemployment has considerable advantages over the more direct survey techniques. These more direct techniques may be biased upwards in their estimates of labor available for nonfarm employment by including seasonally unemployed labor and more often may be biased downwards by not reflecting the type of disguised underemployment shown by the figures in this study.

The presence of a large block of labor that apparently could be removed from agriculture with little effect on the volume of total agricultural production indicates the prime importance, as is generally recognized, of introducing new employment opportunities to areas of the type discussed. It re-emphasizes the futility of introducing to the agriculture of such areas those capital goods whose only value is as a substitute for labor, at least until considerable labor has been drained from the land.

An implication that is perhaps less obvious is that if alternative nonfarm job opportunities are located within the community of surplus labor, allowing that labor to continue to live at its present residence so that it eats from the family food supply as at present, then any positive net wage rate above the marginal product of labor in agriculture would represent an improvement in economic position for the family in question. This suggests that in the short run it may be economically desirable to undertake industrial development even if the wage paid to the industrial labor must be somewhat below that required to provide fully for subsistence. Because it would presumably be expected that the long run would see rising levels of living it would not generally be desirable to commit capital in fixed forms to industries that could not pay at least a subsistence wage over the long term. It might, however, be desirable

[7] Fifty-three percent of this labor is on farms with two or more man equivalents available.

to introduce industries of this type if the fixed capital requirements were very small or were consumed in a relatively short production period, such as is the case in most forms of cottage industry, for example.

The possibility of paying less than a subsistence wage also suggests a way of reducing the total quantity of capital needed to initiate some production processes. Some industries, in the initial stages of production, may not be able to cover all costs and pay a wage higher than the subsistence level. However, these same industries might hold promise of operating more efficiently in later time periods, and at that time being able to pay the going rate of return to the nonlabor factors of production and also to pay a wage to labor considerably higher than the subsistence level. Under such circumstances, if a wage higher than the subsistence level were to be paid at the outset, a considerably larger capital supply would be needed in order to absorb the losses incurred during the early period of operation. This poses a financial problem to the financiers and a real problem to the economy. Extremely high capital costs might militate against such an industry. The problem could be alleviated by paying low wages to the labor force, even, as we indicate may be possible, a wage lower than the level required to provide full subsistence. In pursuing such a wage policy, reliance would be placed on the small improvement in family income that such a wage offers, to attract labor. The family income from agriculture would provide the remaining portion of the subsistence of the industrial labor force. Presumably, as operating economies developed, the wage level could be increased. The opportunity to force part of the support of these new industrial laborers back on other members of the family during this beginning period of industrialization represents a means of increasing returns to capital and of reducing total capital requirements.[8]

It might even be desirable to realize the possibility of paying low wages in cases in which the productivity of labor in new industry was relatively high even in early stages of production. In such cases, low take-home pay to labor would provide higher returns to capital and allow a high rate of internal corporate saving—thus favoring a rapid pace of industrial investment particularly of the capital widening type.[9]

The basic assumption, in suggesting that a less than subsistence wage might be paid, is that the work force can continue to draw part of the

[8] For discussion of the almost insurmountable problem of generating, by orthodox means, sufficient capital within underdeveloped countries to promote economic development, see H. W. Singer, "The Mechanics of Economic Development," *Indian Economic Review*, Vol. I, No. 2, August 1952, page 11.

[9] Clearly, questions of distribution of wealth would occur in such circumstances, so that such a program might be politically acceptable only in the case of state-controlled industries.

subsistence needs from those producing a surplus product on the farm. That such drawing upon others for subsistence could continue would clearly require that the new industry be so located that the work force could continue to reside in its old residence. The shifting of the labor supply to an urban area some distance away would of course prevent this. For industry in urban centers, the wage level would have to be at least at the subsistence level, and presumably somewhat higher, to attract labor from the present rural situation.[10] The size of firm that can use labor that continues to reside in its rural residence will of course be a function of the population density and the nature of the available means of transportation.

Summary

In underdeveloped countries, under certain conditions dominant forces appear to cause an equalizing of the average product of agricultural labor among farms and areas. Due to differences in production functions, this leads to variation in the marginal productivity of labor among farms and areas. The highly productive soil areas tend to have the largest block of labor with marginal productivity *circa* zero. The farm data from Bang Chan, Thailand are consistent with this hypothesis. This suggests the desirability of locating nonfarm employment opportunities in the highly productive soil areas. Such areas also tend to be regions of more highly developed transportation systems and regions of densest total population. The fact that any positive wage may represent an improvement in the economic position for a large number of people in such an area suggests the possibilities of establishing small-scale industry even if the returns to labor in these pursuits are very low—even to the point of being lower than that required to provide full subsistence. This also indicates possibilities for encouraging investment and providing a source of investment funds through low wage rates in factory industry.

[10] Singer, *op. cit.*, and Ragner Nurkse, *Problems of Capital Formation in Underdeveloped Countries*, 1953, pages 9, 37, *et seq.*, emphasize the importance of the food transfer problem from rural areas to the urbanized areas of industrialization. Location of industry in the areas of dense rural population would seem to offer a useful approach to this critical problem as well as to that of capital formation.

TEN YEARS OF COMMUNIST PLANNING IN POLISH AGRICULTURE

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AGRICULTURE has been the most troublesome branch of the national economy for the Polish planners, falling short of the production goals assigned to it and resisting most strongly the structural changes introduced by the communists. This note, primarily concerned with the execution of production plans and the over-all performance of Polish agriculture,[1] is based mainly on Polish official periodicals and other publications. Although statistical data on Polish agriculture are neither complete nor probably very accurate, several problems and shortcomings have been discussed quite frankly by the Polish communist leaders, particularly since the ninth meeting of the central committee of the party which inaugurated the so-called new course in economic policy in the fall of 1953. This enables the writer to present a fairly accurate picture of the situation in Polish agricultural, although it is not abundantly supported by quantitative data.

There have been two distinctive periods in the postwar history of Polish agriculture, and in each of them two subperiods can be distinguished.

The 1945-1949 Period

The first two postwar years were the years of carrying out the radical land reform and a wide resettlement program on the newly acquired western territories. War destruction, territorial changes and great shifts of population made any planning next to impossible. The main concern of the government was to increase the area of cultivated land and to secure food supplies for the urban population by organizing levies in kind and by obtaining foreign aid.

During the execution of the Three Year Plan of National Reconstruction (1947-1949) national goals were set for each year but they were not apportioned below the level of the province. Direct planning in agri-

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[1] The structural changes in Polish agriculture did not differ greatly from those in other countries behind the iron curtain. These have been presented in a general manner by L. S. Schweng, "Recent Agricultural Developments in Eastern Europe," *Journal of Farm Economics*, Vol. XXXIII, Feb. 1951, pp. 40-54. More recently E. Koenig described postwar land reform in Poland in *Foreign Agriculture*, July-August 1955, pp. 139-144, and the problem of collectivization was discussed at a special conference devoted to this subject at the University of Kentucky in 1955.

culture was limited to state farms which at that time covered less than 10 percent of land used for agricultural purposes. Collectivization began only in 1949 and the two hundred of the so-called producers' cooperatives that harvested their first crops in that year still had the character of a more or less voluntary experimentation.

Production of private farms was influenced through education, propaganda, material aid and economic incentives. The Peasant Self Aid Association—an organization created and entirely controlled by the communists—was one of the main instruments of carrying out governmental agricultural policies. A fast expanding network of rural cooperatives of that association was gradually taking over the task of supplying peasants with all nonagricultural products as well as of purchasing from them most of the main farm products for the government which monopolized the wholesale trade. Mechanization of agriculture was fostered by organizing cooperative tractor and machinery centers to which individual farmers or whole villages could apply for loan of tractors and other agricultural machinery.

On the whole the government was more interested at that time in increasing the aggregate quantity of production, than in influencing its composition, and regional location. But cultivation of some industrial crops, mainly flax and hemp, was at that time already successfully promoted by means of advanced government contracts with farmers.

Although the Polish government's claims of fullfilling the Three Year Plan by more than 100 percent and of surpassing the prewar Poland's per head agricultural production by about 20 percent in 1949 may have been somewhat exaggerated, the fact was that Polish agriculture made a remarkable recovery. It was still not greatly hampered by government intervention, and had the advantage of much more favorable price relationships than before the war. Due to increased food supplies, the very imperfect rationing system could be abolished in 1948, and after a very good harvest in 1949 Poland returned as a food exporter on the International market.[2]

The 1950-1955 Period

The plan. The principal task of the Six-Year Plan of Economic Development and Building the Foundations of Socialism in Poland was to develop the means of production. Although the main emphasis was placed on the intensive industrialization of the country, an all-sided development of agriculture was to insure, according to the chief Polish

[2] The area in contracted crops increased from 271,000 hectares in 1947 to 490,000 hectares in 1949 when nearly 800,000 farmers signed contracts covering the following commodities: sugar-beets, potatoes for industrial purposes, succory, rape seeds, poppy seeds, flax, hemp, hops and tobacco.

economic planner, H. Minc, "a rising standard of living of the growing urban population by supplying it with the necessary quantity of consumers' agricultural goods and a growing quantity of agricultural raw materials for the developing industry."[3] The plan called for a steep overall increase of agricultural output, 50 percent above the 1949 level, and for shifts in emphasis among products and regions.

Livestock production was planned to rise by 68 percent in excess of the 1949 level, much faster than production of crops. The number of

TABLE 1. LIVESTOCK NUMBERS: PLANS AND ACHIEVEMENTS

Kind of Stock	Six-year Plan 1949*	1955	Increase	1953	1954	Revised plan 1955
	thousand	thousand	percent	million	million	million
Horses	2,538.2	3,000	18			
Cattle	6,365.1	9,500	49	7.4	7.7	8.0
Pigs	5,836.7	10,500	72	9.7	9.7	10.7
Sheep	1,621.1	3,800	134	3.3	4.1	4.2
Poultry	77,173.3	105,700	36			

* Figures for 1949 are calculated from the 1955 targets and percent increases as given in the law of the plan.

sheep and hogs was expected to rise most rapidly (Table I), as hogs were considered as the main source of meat supply.

Crop production was to increase by 38 percent by putting all suitable land into cultivation and by raising the yields of various crops by 20 to 40 percent. The share of fodder crops and industrial plants was to be expanded at the expense of cereals, mainly rye (Table II). These would have been desirable changes. The production targets on the whole did not go beyond what was physically possible to attain,[4] providing the government and farmers worked in harmony and did everything to achieve them.

Execution of plans, 1950-53. As in the previous period, production of the state farms has been under year-to-year planning and control of the Ministry of State Farms. Production of the rest of the socialized sector and of individual farms came under territorial planning of the national councils.[5] These councils participated in preparation and execution of

[3] Hilary Minc's report delivered at the Fifth Plenary Session of the Central Committee of the Polish United Workers Party on the 15th of July, 1950.

[4] The yields scheduled for 1955 would be only one-eighth higher than prewar on the same territory and would approximate those obtained in Czechoslovakia in the 1930's. The number of cattle and hogs per head of population would be a little higher than in Czechoslovakia, Germany or France in 1930's.

[5] These are a substtiute for local self-government. Since reorganization of 1950 the presidia of the national councils have been the executive organs of the central government according to the communist principle of unitary power of state.

the yearly plans. In the case of producer cooperatives, an attempt was made to work out detailed plans of all yearly activities with the help of an agricultural instructor from the district national council or from the nearest state machinery center. The main task of the state machinery centers has been to provide technical aid for collective farms, and also to promote mechanization and collectivization of agriculture. Planning of the agricultural production of collective farms has been less direct than that for state farms. The management of a cooperative can, at least in theory, foreward its own suggestions to the National Council and influence details of the plan. The effectiveness of this planning was diminished by the fact that most of the crops were usually sown before the final version of the plan could be worked out. By the end of 1952

TABLE 2. AREA IN DIFFERENT CROPS IN PERCENTAGE OF TOTAL AREA SOWN

Crops	1949	Planned for 1955	Reported for 1953
Grains	65.2	60.2	61.7
Wheat	9.8	10.4	
Rye	34.9	27.9	9.9
Barley	5.7	7.2	
Oats	12.0	11.1	
Mixed and other	2.8	3.6	
Legumes for grain	3.5	4.5	
Fodder	2.9	3.5	
Industrial crops	3.6	4.8	4.9
Potatoes	17.1	16.7	17.0
Fodder	8.9	12.3	16.4 (Fodder and others)
Others	1.7	1.5	
Total	100.0	100.0	100.0

older and better established producers' cooperatives were advised to prepare a three-year plan. In the private sector, which in 1952 still covered more than 80 percent of the land actually used for agricultural purposes, it has not been possible to work out individual plans for about three million peasant farms. As in the previous period "planned regulation" involved a combination of propaganda, economic incentives and governmental regulations. The amount of state interference and compulsion increased greatly.

In 1951 contracting was extended to include livestock, poultry and grain seeds, so that the total area contracted covered more than a million hectares of crop land. In the same year, after a very poor harvest, the first compulsory quotas for delivery of grain and potatoes were introduced. In 1952 these quotas were extended to include the collective farms and new compulsory quotas were announced for livestock and dairy products. Legal private trade in farm products was completely liquidated.

Since January 1953, however, the farmers who deliver the compulsory and contracted quotas are officially allowed to sell the remaining surpluses on a free market, providing they sell directly to consumers.

There were minor programs for promoting expansion of meat production,[6] but since 1951 the main tools for regulating agricultural production and for engineering socio-economic structural changes have been compulsory deliveries, government contracting and purchasing programs which created several price levels for most farm products. Compulsory deliveries of quotas are established for staple farm products. These quotas do not exhaust the marketable possibilities of the farms but they provide the government with considerable supply of foods at a very low fixed price. Premiums are sometimes added for timely deliveries of the quotas (10 percent in the case of hogs). The government stands ready to buy and offers a considerably higher price for anything that is delivered for sale by farmers above or outside the required quotas even if it was not contracted in advance.

Contracting is primarily used to foster production and to secure delivery of a number of farm products considered of special importance by the government. Farmers may contract to deliver extra quotas of commodities with compulsory quotas (such as milk or meat) or on other products to which compulsory quotas have not applied (such as sugar beets, oil seeds, tobacco). In both cases relatively high prices and accompanying special privileges in obtaining coal, feeding stuffs, etc. are supposed to attract an adequate number of volunteers. This influences the composition of agricultural output and its location without outright compulsion.

The collective farms and small peasant farms have priority in obtaining more profitable contracts while the peasants on larger holdings, must, due to the progression of the compulsory deliveries, sell most of their products at the lowest price. This price has been kept constant since 1950 and hardly covers the cost of production. For example, the price of compulsory deliveries of rye, the most important grain, was 60 zlotys per hundred kilograms in 1953, the same as in 1950. Government price for rye delivered in excess of the compulsory quotas rose from 72 to 120 zlotys per hundred kilograms between 1951 and 1953. The free market price, always somewhat higher than the government price, in the spring of 1953 climbed to 224 zlotys (Province of Ponan) and to 271 zlotys after the poor harvest of that year. Thus the compulsory deliveries serve as a tax in kind imposed on agriculture for the sake of promoting industriali-

[6] The two-year "H" plan for increased meat production involved setting up special stock breeding farms, propagating rabbit breeding among peasants and town workers, and organizing hog fattening plants by dairies and collective feeding establishments. All scraps would be collected and used for fodder.

zation. Their differentiation according to the class of the soil and size of the farm (with some progression) practically eliminates the income that would normally come from the ownership of the land. This also lowers the standard of living of individual farmers to the level of a farm laborer. This agrees with the general communist doctrine that labor should be the only source of income, and makes the peasants more susceptible to the propanganda and pressure for collectivization.

Much higher prices for the products delivered in excess of the required quotas are expected to stimulate the efforts of farmers. But the fear that in case of increased production and sales the compulsory quotas might be increased tends to deter the farmers from expanding production. There was a steady increase in supplies of means of production such as fertilizers[7] and farm machinery. Production lagged behind the planned figures, however, and the discrimination against individual farmers, particularly against those who were more prosperous decreased the effectiveness of these supplies.

The communist planning in Poland in the early 1950's was on the whole quite successful in changing the composition of agricultural output (Tables I and II) but failed miserably in raising its over-all level. During the first four years of the Six-Year Plan the total value of agricultural production increased by 10 percent. Animal production increased by 23 percent and plant production by only 2 percent. Crop yields did not rise in excess of the 1949 level. As planned, the increase in animal production was much greater than the increase in plant production, and the share of animal production in the total agricultural production increased from 38.8 percent in 1949 to 42.4 percent in 1953. Composition of crops closely followed planned changes. The proportion of acreage under industrial crops was larger in 1953 than was planned for 1955. The decrease of the area under grains with no compensating increase of yields per acre brought about the necessity of importing grains. The increase in number of livestock was still inadequate to satisfy the increasing home demand for meat and dairy products. This brought the threat of a general food shortage.

The new course, 1954-55. The so-called New Course inaugurated at the ninth meeting of the central committee of the party in the fall of 1953[8] brought about increased assignments of resources for agricultural

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[7] According to S. Makowski, Ksztaltowanie Proporcji Planu Produckcji Rolnej," *Gospodarka Planowa,* June 1954, fertilizer supplies in 1953 were 64 percent larger than in 1949.

[8] Encouraged by the examples of self-criticism at the Kremlin, Polish communists admitted at that meeting that the failure in agriculture was due to the inadequate government aid, incompetence of agricultural leaders, and the difficulty of simultaneously carrying out collectivization and substantially increasing the level of production.

production, a lessening of discrimination against individual farmers, including kulaks, with respect to supplies of seeds, fertilizers and machinery, and some new incentives for increased production efforts. All investments in agriculture were to be 45 percent larger in 1955 than in 1953 and it was hoped to raise the over-all agricultural production by more than 10 percent. The main emphasis in the revised plans was placed on higher yields but some increases in livestock were also envisaged. The supply of farm machinery increased by 41 percent in 1954 in comparison with 1953 supplies. Supplies of fertilizers increased by 10 percent and building materials by 23 percent according to official Polish government reports. Some long range credit, building materials and, for the first time, tractors and heavy machinery became available for individual farmers. Somewhat better results were achieved in that year (1954) although neither the investment program nor the production targets were fully attained. The value of over-all agricultural production increased by 4.8 percent, crop production increased by 6.7 percent and animal production by 2.4 percent.

A further increase in aid for agriculture was signaled by the Polish communists early in 1955, but they were careful to stress that this did not mean weakening of industrial development and that the shifting of resources to production of consumer's goods was only temporary. A 6.2 percent increase in value of total agricultural production was planned for 1955. Even if this were realized the Six-Year Plan, which has more than doubled industrial potential and output of the country, would raise the agricultural production slightly more than 20 percent. This is less than half of what was originally planned. In spite of many privileges with respect to obtaining necessary means of production, the productivity of the socialized sector (now one-fourth of agricultural land) as measured by the value of output per acre is not higher than on the peasant farm. Yields of grains are somewhat higher on collective and state farms, and the quality of livestock of the state farms is probably higher than on peasant farms. But the yields of potatoes and root crops, and the densities of livestock, particularly cows, horses and poultry of individual farms in Poland, are still superior to collective farms and state farms. A somewhat higher production per farm worker and greater marketability of farm products seems to be the only economic gain of collectivization.

If the next plan brings a renewed emphasis on heavy industry and increased pressure for collectivization, the gap between development of industry and agriculture will widen no matter what the official production targets for agriculture may be. Imports of foods, at least grains, for the population of Poland may become a permanent feature of Polish foreign trade.

THE WHOLESALE COMMISSION BUSINESS IN THE ALABAMA BLACK BELT, 1875-1917

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IN THE cotton states of the South, following the Civil War, the wholesale and commission business flourished. It was a part of the cotton credit system, which was the base of the economy in that region during the period 1875-1917.

This study is concerned with the operation of that business in a part of Alabama known as "The Black Belt." It is an area of rich soil, which in earlier days had attracted planters and slaveholders. Although the Negro population is large, tending toward eighty percent, the name "Black Belt" is derived from the black limestone soil.[1] The system of business in this section may well be considered typical of business in other old plantation areas of the South.

A cotton farmer usually made credit arrangements with a general merchandise store, which extended credit for his household and farm supplies for a year's time. Security for the so-called "advances" was the farmer's cotton crop, and settlement was made at harvest time.

The storekeepers themselves relied on long term credit. They bought supplies from the wholesale houses in the larger towns and cities, frequently selling their bales of cotton to the same dealers.

Prior to the Civil War, Mobile was the chief cotton market and wholesale distributing center in Alabama,[2] and after the war much of its trade was revived. In 1884-1885 Mobile had twenty-two cotton factors, eighteen cotton brokers and buyers, thirty-four commission merchants, eighteen wholesale grocers, three wholesale dry goods stores, four wholesale clothing houses, four wholesale dealers in cigars and tobacco, and five wholesale boot and shoe dealers.[3] These merchants and traders dealt with a large river trade that encompassed much of the territory drained by the Alabama and Tombigbee Rivers as well as the area served by the railroads. As time went on, however, Mobile became less important as a wholesale center. The railroads made the inland planters and merchants less dependent on the rivers for transportation, and consequently made it possible to ship their cotton to other centers than

[1] The strip of rotten limestone soil runs through the following counties, which are considered Black Belt counties: Bullock, Dallas, Greene, Hale, Lowndes, Montgomery, Perry, Sumter, Marengo, and Wilcox.

[2] C. S. Davis, *The Cotton Kingdom in Alabama* (Montgomery, 1939), pp. 160, 161.

[3] *Alabama Gazetteer and Business Directory, 1884-85*, pp. 799 ff., 817, 827, 828, 835, 851, 903.

Mobile. Montgomery, Selma, Birmingham, Tuscaloosa, and Meridian came to share much of Mobile's trade and glory. By 1910-1911 *Young's Directory* listed for Mobile only eight wholesale produce dealers,[4] two wholesale meat dealers, three wholesale hardware dealers, five wholesale groceries, two wholesale fruit dealers, five wholesale flour dealers, one wholesale dry goods establishment, and two cotton buyers and factors.[5]

Montgomery, on the Alabama River, had also a large share of the steamboat trade in the early days. As the largest city in the Black Belt, it was the principal distributing point both by river and by railroad. After Montgomery became a railroad center following the Civil War, it was difficult to maintain steamboat traffic above Selma to Montgomery. Before the coming of railroads, ten to twenty steamers plied the waters of the Alabama, but after the Civil War a single steamer landed weekly at the Montgomery wharf. Intermittent efforts to reorganize the Montgomery river trade succeeded at times in restoring a larger number of steamers. Such an effort was the Montgomery Trade Company, which, in 1886, succeeded in bringing three of the five steamers that came to the Montgomery wharf weekly.[6] This resulted in a reduction of freight rates on incoming goods and reduced the cost of shipping compressed cotton to Mobile.[7] The Montgomery Trade Company was owned by Montgomery merchants, and its boats made connection with steamers running between Mobile and New York, Bremen, and Liverpool. Goods were shipped to these distant ports on "through" bills of lading.[8]

By 1903 the wholesale grocery dealers had their business organized into a price fixing combination. Representatives of the eight wholesale grocery houses of Winter, Loeb Grocery Company; Schloss, Kahn; Greil Brothers Company; W. F. Vandiver Grocery Company; Hobbie and Teague Company; Seligman and Marx; W. B. Jones and Ray; and W. M. Hudson and Company met every Wednesday and fixed wholesale grocery prices for the week. These prices were given to the salesmen on the following Saturday, and any firm caught violating the price agreements was fined $1,000, the fine being divided among the other members. This local combination was a member of the southwide Southern Wholesale Grocers Association, which engaged in similar price fixing activities throughout the South.[9]

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[4] Considered by the directory to include "commission merchants."
[5] *Young's Directory, 1910-1911*, pp. 524, 526, 529, 531, 544, 550.
[6] *Montgomery Daily Advertiser*, September 27, 1886.
[7] *Ibid.*, September 27, 1886.
[8] *Montgomery Daily Advertiser*, July 5, 1887; *Montgomery City Directory, 1888*, p. 11.
[9] Statement by J. M. Hobbie, employee of Hobbie and Teague Company, son of the joint owner of the firm.

The wholesale merchants "carried" their customers, the retail merchants, for a year, charging six percent interest after an initial "free" month. Wholesale grocery profits were ten percent gross, business costs being rated at three and one-half percent.[10]

The Montgomery Journal claimed in 1898 that the Montgomery wholesale trade area extended over 25,000 square miles in Alabama, Mississippi, Georgia, and Florida, and that her total annual trade value was about $40,000,000.[11] Greil Brothers was in 1919 the oldest of the post-Civil War wholesale groceries, dating from 1865. Among the other firms of long standing were J. M. Hobbie Grocery Company, Schloss and Kahn, Winter Loeb Grocery Company, and Seligman and Marx.[12]

The most typically Black Belt of the wholesale markets was Selma, located fifty miles west of Montgomery in the heart of the prarie section. The stores located here served the counties of Dallas, Perry, Marengo, Wilcox, Monroe, Butler, Lowndes, Autauga, Chilton, Bibb, Shelby, Hale, Clarke, Washington, Talladega, and Calhoun.[13] Eight wholesale grocers, eight commission merchants, four cotton factors, and seven cotton brokers and buyers administered Selma's wholesale trade in the eighties.[14]

The wholesale grocery business in Selma was being conducted in 1905 by nine firms with a joint capital of more than $1,500,000 and with a joint trade amounting to more than $6,500,000 annually. The wholesale and retail dry goods business amounted to $1,500,000 per year, the wholesale drug business to $750,000, and the hardware business, represented by four wholesale and two retail firms, amounted to $750,000 annually.[15]

Among the larger Selma firms in the earlier part of the period were H. C. Keeble Company, wholesale grocers; A. M. Fowlkes and Company, wholesale and retail hardware; S. Maas and Company, wholesale grocery and cotton firm; R. C. Keeble and Company, wholesale provision merchants and sellers of cotton; C. W. Hooper and Company, wholesale grocers; Oberndorf and Ullman, wholesale and retail dry goods; Adler Grocery Company; Holt, Starr, and Company, wholesale grocery; and others.[16] Cawthon and Coleman, established in 1869, became one of the leading wholesale drug houses of the state. The company by 1888 did a

[10] *Ibid.*

[11] *Montgomery Journal*, August 31, 1898.

[12] *Montgomery Advertiser*, October 22, 1919.

[13] Mobile and Ohio Railroad, *The Great South*, p. 2; Ledger of V. B. Atkins Company, Selma, Alabama, 1894.

[14] *Alabama Gazetteer and Business Directory, 1884-1885*, pp. 830, 835, 836, 903.

[15] Selma *Morning Times*, May 11, 1905.

[16] *Alabama Gazetteer and Business Directory, 1884-1885*, p. 903; Mobile and Ohio Railroad, *The Great South*, 1888, pp. 9, 10; *Southern Argus*, January 5, 1872; *Alabama Baptist*, October 20, 1881.

business of $100,000 per year, and drew its trade from a radius of one hundred miles around Selma.[17]

The center of most of the wholesale business of the city was Water Street, which ran parallel to the Alabama River. Many of the stores had wharfs at their rear by which cotton was loaded for its trip to Mobile. By 1911 Water Street was still the center of the wholesale business, but many of the names had changed. There were then such firms as M. Hohenberg and Company;[18] W. B. Atkins Grocery and Commission Company; R. H. and W. C. Agee, wholesale grocers and cotton sellers; C. W. Hooper and Company, wholesale grocers and cotton commission merchants; and others.[19]

The merchants of Water Street charged the retail merchants a commission of two and one-half percent to sell their cotton. Ten to fifteen percent interest was charged on advances of merchandise made to the retail merchants.[20]

Demopolis had eight wholesale houses in 1910, including three wholesale groceries, three wholesale hardware stores, and a dry goods jobbing house. In addition there were several semijobbing concerns doing considerable business.[21] There were also wholesale houses at Marion,[22] Union Springs, and Eutaw, as well as at Tuscaloosa and Meridian outside the Black Belt.[23]

Boll weevil infestation reached the cotton fields of Alabama in 1916 and so seriously threatened cotton production that many one-crop cotton growers turned to diversified farming. As World War I brought large demands and high prices for food crops, many farmers allowed the abundant wild grasses natural to the prarie lands to grow in their former cotton fields, as pastures for cattle. This change from cotton to cattle and other crops caused a decline in cotton credit business, resulting in gradual and continued loss of business for the wholesale and commission merchants. During the twenties, cotton production revived, but the low prices of the depression of the thirties caused another slump. Thereafter the change from cotton to cattle became a fixed trend. Government crop loans replaced the system of crop advances. The wholesale commission business had to change too, and deprived of its cotton credit base, much of this type of business died.

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[17] Mobile and Ohio Railroad, *The Great South* (1888), p. 9.

[18] Established in 1879.

[19] *Selma Mirror*, June 28, 1911.

[20] Statement by James W. Moore, former wholesale grocery merchant on Water Street, Selma; cotton abstract, V. B. Atkins and Company, Selma, Alabama, 1894-1906; Irby Pope, Probate Judge, Perry County, Alabama.

[21] *Demopolis Express*, November 15, 1894; *Demopolis Times*, October 13, 1910.

[22] *Marion Commonwealth*, September 23, 1875, October 7, 1880; *Marion Standard*, January 11, 1906.

[23] *Forkland Progress*, March 21, 1891 and *Union Springs Herald*, December 18, 1909.

SIZE OF FARM AND FARMING EFFICIENCY IN NORTHEASTERN NEBRASKA*

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University of Nebraska

IN AN area in which farm incomes are considered to be at a relatively low level, two alternative types of organizational adjustments may be utilized by farmers in attempting to achieve more adequate income from farming. These are (1) intensification of the farming systems on a given acreage and (2) gaining operational control of more land through lease or purchase with the addition of other associated inputs. This discussion is focused on some of the implications of these adjustments.[1]

The geographical area under consideration is in the steeper part of the loess hills of northeastern Nebraska. The topography is hilly, and the natural drainage pattern has a tendency, in places, to form deep channels or gullies. The control of erosion is a major problem in the area.

Census data from Dixon County illustrate changes (Table 1) that have taken place in farm sizes in the problem area. Between 1920 and 1950 the average size of farm increased from 191 acres to 206 acres, or an increase of 8 percent. However, changes in specific size groups are more significant. There has been an increase in number of farms of less than 50 acres, which units are usually operated by part-time operators. In contrast there has been a slight decrease in number of farms of 50 to 99 acres in size, and a substantial decrease (8 percent) in the number of farms of from 100 to 174 acres in size. Despite the decreases, however, in 1950 there were 423 farms of from 150 to 170 acres in size, or 29 percent of the total number. In fact, the group of 150 to 170 acres actually

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[1] Although there are differences in the methodological approach, the conclusions of this paper are similar to those in Orlin J. Scoville, *Relationship between Size of Farm and Utilization of Machinery, Equipment, and Labor on Nebraska Corn-Livestock Farms,* USDA Technical Bulletin No. 1037, 1951. Other literature indicative of the contemporary interest in the topic to which this paper is addressed include: I. F. Fellows, et al., *Production Efficiency on New England Dairy Farms, 2. Economics of Scale in Dairying,* Storrs Agricultural Experiment Station Bulletin 285, 1952; John H. Bondurant and James E. Criswell, *Economics of the Small Farm,* Kentucky Agricultural Experiment Station Bulletin 563, 1951; Earl O. Heady, "Technical Scale Relationships and Farm Size Policy," *Southern Economic Journal,* 19:353-64, 1953; Heady, Dean E. McKee, and C. B. Hover, *Farm Size Adjustments in Iowa and Cost Economics in Crop Production for Farms of Different Sizes,* Iowa Agricultural Experiment Station, Research Bulletin 428, 1955; and Kenneth L. Bachman, "Changes of Scale in Commercial Farming and Their Implications," *Journal of Farm Economics,* 34:157-72.

increased in number from 1945 to 1950. During the 30-year period, the group of 175-259 acres did not increase. However, a substantial increase took place in the number of farms of 260 to 499 acres, as well as in the group of from 500 to 999 acres.

Since 160 acres is the modal size of farm in the area, and in view of the current interest in adjustments in size of smaller farms, a primary focus in this analysis is the economic organization of this size.[2] Evidence is presented concerning the commonly held belief that there are large economies associated with increases in farm size in excess of 160 acres.

The usual theoretical relationship of costs and size of farm furnishes the economic framework to which this analysis is related. We must distinguish at this point between economies of scale and cost economies

TABLE 1. DISTRIBUTION OF FARMS BY SIZE GROUPS, DIXON COUNTY, 1920–1950[1]

Size group (acres)	1920		1930		1940		1945		1950	
	No.	%	No.	%	No.	%	No.	%	No.	%
0– 49	58	4.0	99	6.5	109	7.4	119	8.2	115	7.9
50– 99	153	10.6	148	9.7	141	9.6	108	7.5	120	8.3
100–174[2]	636	44.2	646	42.2	575	39.0	532	36.9	517	35.8
175–259[3]	331	23.0	342	22.2	318	21.5	344	23.9	338	23.3
260–499	226	16.4	268	17.5	291	19.7	295	20.4	320	22.1
500–999	26	1.8	27	1.8	40	2.7	44	3.0	35	2.4
1000 & over	0	0	1	.1	1	.1	2	.1	3	.2
Total	1,439	100.0	1,531	100.0	1,475	100.0	1,444	100.0	1,448	100.0

[1] Based on U. S. Census.
[2] 100–179 acres in 1945–50.
[3] 180–259 acres in 1945–50.

among farm businesses. True economies to scale are involved only if all of the factors of production are increased in the same proportion. Thus, if X quantity of resource A, and Y quantity of resource B are used in producing a product Z, a linear scale relationship would be indicated if 2X plus 2Y were used in producing two units of product Z. In our analysis we are not actually concerned with economies to scale in the true sense, but rather with economies associated with proportionality adjustments.[3] The economies in one size of farm as compared with another are probably related for the most part to more efficient utilization of power, machinery, buildings, labor, and management.

[2] Presumably operators of farms of 100 acres or less either farm on a part-time basis or use intensive systems quite different from the systems of farms of 160 acres or larger. The number of farms of between 100 acres and 160 acres in size is comparatively small.

[3] For a discussion of this point see Earl O. Heady, *Economics of Agricultural Production and Resource Use*, New York; Prentice-Hall, 1952, Chapter 12.

The empirical data used in this analysis were obtained by field interviews of twenty-nine 160-acre farms, twenty 240-acre farms, and sixteen 320-acre farms drawn at random from all farms in these size groups respectively in the problem area. The sample farms were restricted to one soil association—Moody-Crofton—so that size of farm or intensity of production would not be confounded with varying soil patterns among the sample farms.

Organizational Characteristics

A comparison of land use, crop production, resource structure, and financial results for the three sizes of farms under examination is given in Table 2. Generally speaking, the crop combinations among the three groups were similar, and the total feed production was proportionate to total acreage. The 160-acre farms averaged 24 feed units per acre in 1950, the 240-acre group averaged 23, while the large farms averaged 22 feed units per acre for all acres in the farm.

All three groups had, on the average, similar composition with respect to proportions of funds invested in livestock that consumed forage as compared with livestock that consumed grain. The average investment of all livestock per acre was $25 on the 160-acre farms, $25 on the 240-acre farms, and $24 on the 320-acre farms.

In terms of commitment of resources to machinery and buildings there are some differences, as might be expected. The investments per acre in machinery were $19, $18, and $16 in the three groups, in ascending order of size. The 240-acre and 320-acre farms had more tractors, pick-up trucks, and corn pickers than the smaller farms. The corresponding investments in buildings per acre were $42, $36, and $25. The estimated value of the land on the 240-acre farms was $8 less than in the case of the other two groups.

A substitution of capital for labor is apparent on the larger farms. The capital investment per man-year was $15,190 on the 160-acre farms, as compared to $19,040 and $19,840, respectively, in the larger groups. An inspection of the total capital investments, as well as total labor usage during 1950, indicates that the commitment of resources of these two classes was not proportional to acreage among the three size groups. The capital investments per acre were $153, $138, $134 for the three groups in ascending order of size. The respective figures for man-years per acre were .10, .073, and .068. As can be seen in the financial summary, the volumes of business and net farm incomes are, on the average, nearly proportional to farm acreage among the three sizes.

Cost Related to Volume of Business

Rather than compare simple average costs for the three size groups, it is more meaningful to derive cost curves for each size of farm and

TABLE 2. LAND USE, CROP PRODUCTION, RESOURCE STRUCTURE AND FINANCIAL RESULTS ON THREE SIZES OF FARM IN NORTHEASTERN NEBRASKA, 1950

	Size of farm		
	160 acres	240 acres	320 acres
	Land use & crop production		
Grains			
Corn (acres)	61.7	85.4	116.0
Small grain (acres)	43.1	67.7	70.6
All grain (acres)	104.8	153.1	186.6
Per cent grain acres in rotation	74%	74%	73%
Forage			
Hay & rotation pasture	36.8	54.2	68.6
Per cent of rotation	26%	26%	27%
Permanent pasture (acres)	7.6	14.8	49.0
Other land	10.7	14.5	15.8
Total acres	159.9	236.6	320.0
Feed units of grain produced[1]	2,873	4,379	5,546
Feed units of hay & pasture	1,024	1,186	1,485
Total feed units	3,897	5,565	7,031
	Resource structure		
Capital invested in:			
Grain consuming livestock	$ 1,234	$ 2,104	$ 2,136
Forage consuming livestock	2,751	3,909	5,649
Total livestock	3,985	6,013	7,785
Machinery	3,064	4,435	5,600
Buildings	6,655	8,523	7,972
Land	10,763	14,160	21,500
Total fixed assets	17,418	22,683	29,472
Total capital invested	$24,467	$33,131	$42,857
Labor use—months	16.1	17.4	21.6
Capital per man year	$15,190	$19,040	$19,840
	Financial results		
Volume of business	$ 4,490	$ 7,073	$ 8,417
Operating expenses	1,150	2,032	2,323
Machinery depreciation	503	764	881
Net operating income	2,837	4,277	5,213
Fixed expenses	471	588	943
Depreciation on buildings	328	485	569
Net farm income	$ 2,038[2]	$ 3,204[2]	$ 3,701

[1] One feed unit is the T.D.N. equivalent of a bushel of corn.
[2] Cash rent and interest paid not deducted, in order to put all farms on comparable basis.

compare the cost curves for the three sizes. A convenient measure of unit cost is cost per dollar of output.

Variable costs related to volume

In Figure 1 are shown the average variable cost curves for the three sizes of farm.[4] The variable cost used in this analysis included all of the

[4] The regression lines in Figure 1 were estimated by the use of the exponential equation $Y = aX^b$, where Y = cents cost per dollar of output, and X = output in

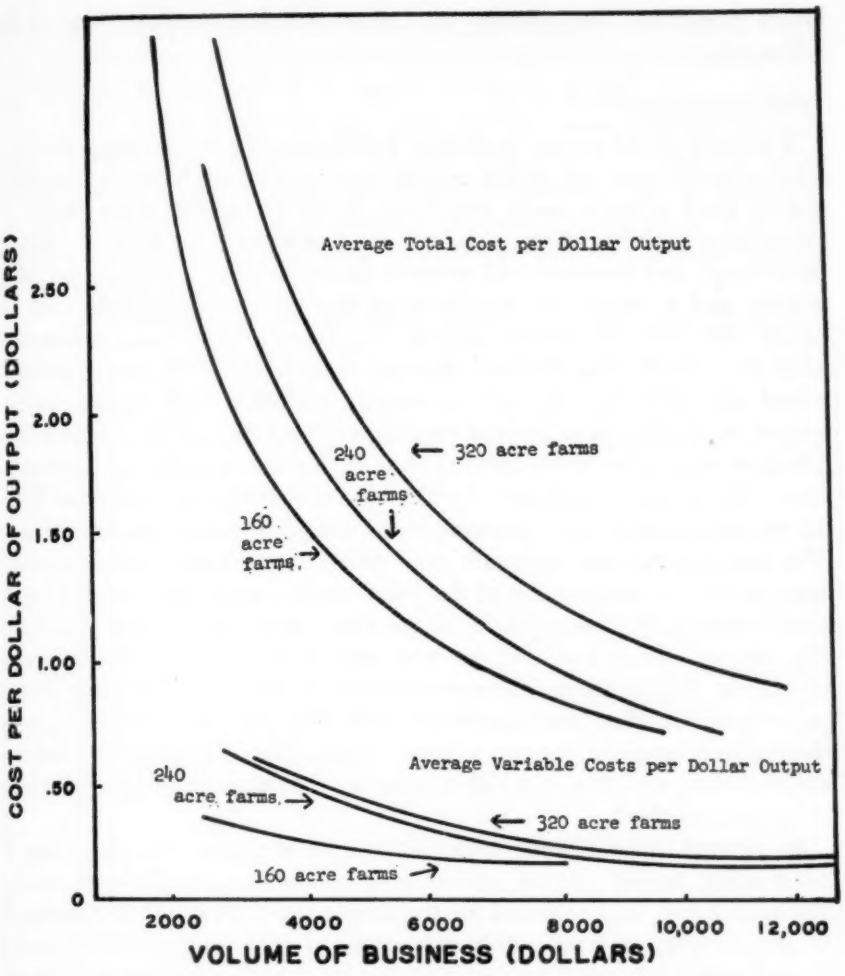

FIG. 1. RELATIONSHIP BETWEEN COSTS PER DOLLAR OUTPUT AND VOLUMES OF BUSINESS ON THREE SIZES OF FARMS IN NORTHEASTERN NEBRASKA, 1950.

cash operating expenses incurred by the farmers in 1950. Operating costs include commercial fertilizer, seed, feeds, fuel and oil, hired labor and custom work, and machinery repairs. Each cost curve declines most rapidly for volumes up to $4,000 or $5,000 per year, after which they tend to level out in each size group. As indicated by the regression lines, the 240-acre farms actually ranged to higher volumes than either the 160-acre farms or the 320-acre farms. The variable costs for the two

dollars per year. Each of the regression coefficients shown was significantly different from zero at the 1 percent level of probability.

larger groups are very similar and somewhat higher than those of the 160-acre farms.

Total average costs

A second set of curves in Figure 1 indicates the relationship between total average cost per dollar output and volume of business. Included among total average costs are taxes, building repairs, depreciation of machinery and buildings, interest on investment in land, buildings, machinery, and livestock (4.3 percent on real estate, 5 percent on other assets), and a charge for the labor of the farmer and members of his family who did not receive wages. The labor charge was estimated at $168 per month. The resource charges upon which these costs are computed are arbitrary, and not necessarily realistic. Thus, it may be improper to charge as much per month for the labor of an operator of a 160-acre farm who is underemployed as for an operator of a 320-acre farm who is fully employed. To the extent that this is done, the farms on which operators are underemployed are penalized in the comparison. The opportunity-cost approach may overestimate total costs somewhat, judging by the relationship of the total average cost curve to the "break even" level of $1. For example, at the rates used, only a small number of the 160-acre farms had average total costs of less than $1 of cost per $1 of output. Unfortunately the data at hand do not allow for more precise procedure. Building and machinery costs may be undervalued by using depreciated original cost as a basis, rather than replacement cost less depreciation, and the cost differences are less than might be true with the second method.

In general the declining total-cost curves represent the spreading of fixed costs among greater volumes of production. Inefficiency on the 160-acre farms as compared to the larger sizes was not demonstrated to any degree, at least within the range of their outputs. Perhaps the costs for the 160-acre farms would have been higher for volumes greater than those shown for this size group. Neither is any great relative efficiency demonstrated by 320-acre farms as compared with the 240-acre size.

The cost curves in Figure 1 are regression lines, passing through the middle of the cost-data distribution. Farmers of each size group who have achieved the most efficient operations with their given plant and capacity should define an economy-to-scale curve, rather than the average farmers. This is illustrated in Figure 2 for the 160-acre farms, where the dotted curve has been drawn to fit the "bottom" of the scatter.[5] If

[5] For a discussion of this point see R. G. Bressler, Jr., "Research Determination of Economics of Scale," *Journal of Farm Economics*, Vol. 27; 528-9, 1945.

similar curves representing the more efficient farmers were fitted to the data for the other size groups, the curve for 240-acre farms would cross the 160-acre farm curve at a volume of about $8,000, and run lower beyond this point. Likewise, the curve for the more efficient 320-acre farms would cross below the 240-acre curve at a volume of about $10,000. These lines probably come close to approximating, in "envelope" fashion, an economy-to-scale curve as illustrated in Figure 3. For comparisons, the points representing mean costs and volumes are plotted for each size group.

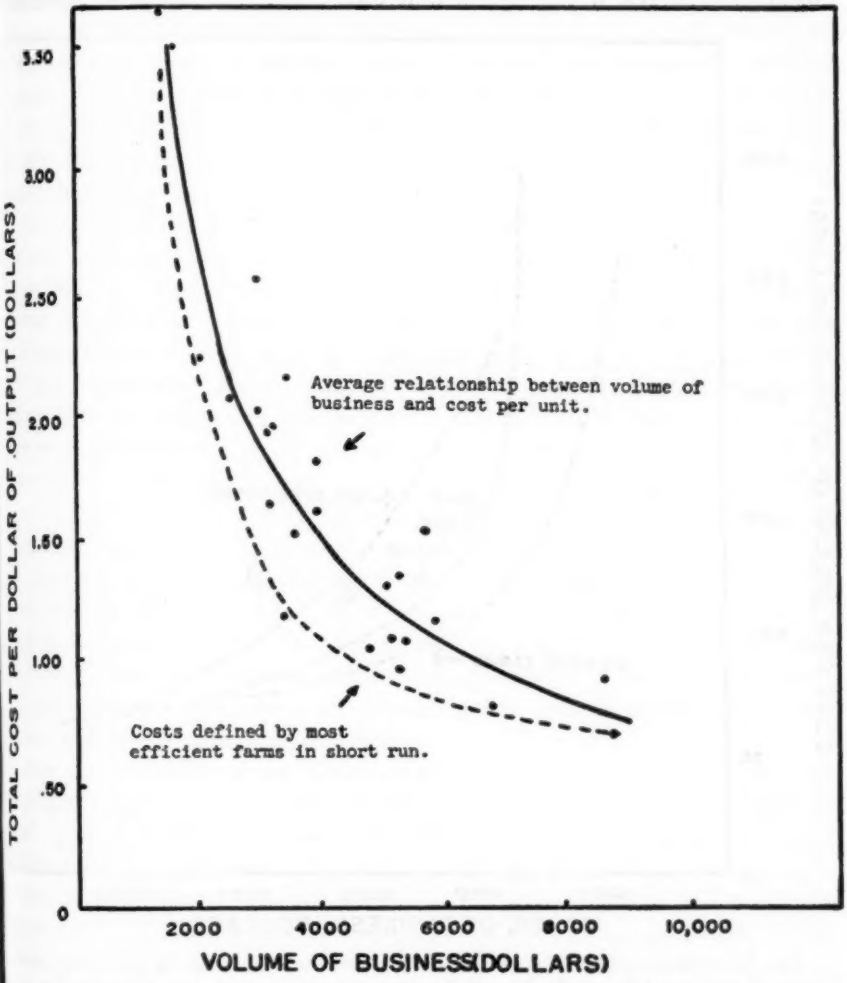

FIG. 2. COMPARISON OF COMPUTED REGRESSION RELATIONSHIP BETWEEN VOLUME AND UNIT COSTS, AND CURVE DEFINED BY LOW-COST OPERATORS, 160-ACRE FARMS IN NORTHEASTERN NEBRASKA, 1950.

The comparisons shown in Figure 3 point to the possibilities of increasing the profitability of 160-acre farms by means of measures that reduce costs with no change in volumes of business, or that increase both total costs and volume of business. In the study area, inputs like commercial fertilizer and legumes have been greatly under-exploited. In studying the costs and returns at 1950 prices associated with some possible adjustments on the 160-acre farms, which include cropping systems with more rotation hay and pasture, contouring and terracing, the use of more fertilizer, and additional livestock to use up feed, particularly roughages, it was found that the returns per dollar of additional

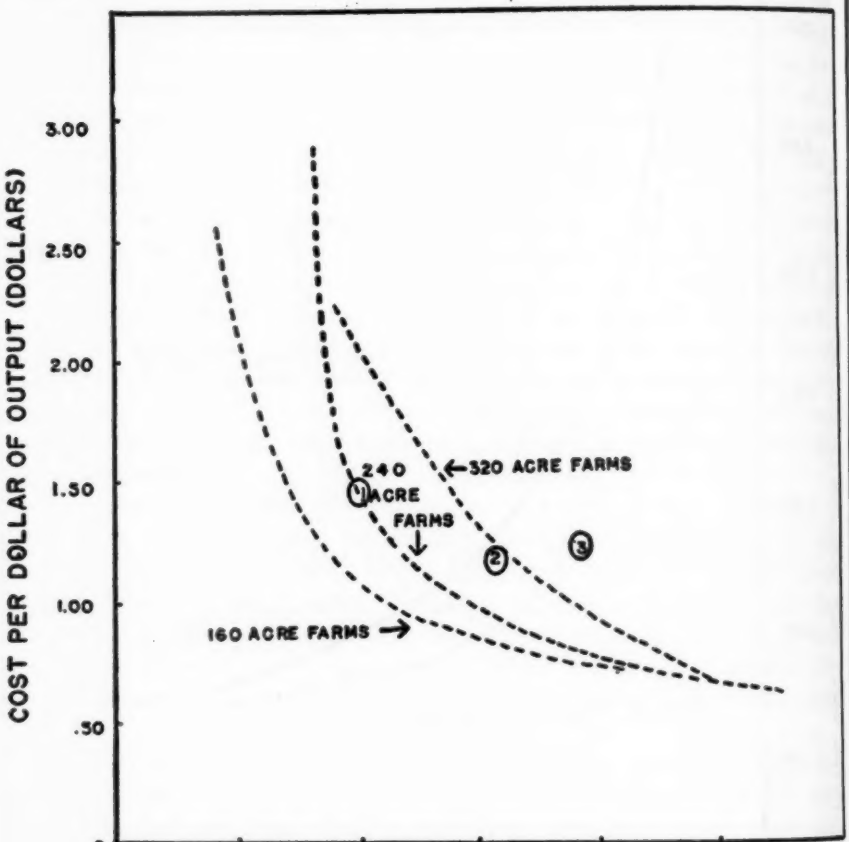

FIG. 3. AVERAGE COST CURVES ESTIMATED FROM MOST EFFICIENT FARMS OF THREE SIZES. (Locations labeled 1, 2, and 3 represent mean costs and volumes for 160-acre, 240-acre, and 320-acre groups, respectively.)

annual inputs would vary from $2.39 to $3.46 among a series of possible livestock systems. The additional annual inputs associated with these adjustments would range from $1,448 to $2,212 per farm.

The 160-acre farms also have the alternative of adding more acres in an effort to increase volume and net income. The 240-acre farms in the study had, on the average, $10,075 more capital invested and used 1.3 more man-months of labor than did the 160-acre farms. They applied additional annual inputs in the amount of $1,784, for which the additional gross return was equivalent to $1.45 per dollar of additional input. However, this rate of return is less than the rate associated with intensification on the 160-acre unit. Of course, less management skill may be required to operate a 240-acre farm somewhat less intensively than to "push" a 160-acre farm to a high degree of intensity. On the other hand, more economic risk may be associated with increase in size, particularly if the adjustment is made with a large proportion of capital borrowed under long-term loans.

We recognize that, in interpreting these comparisons, we do not have as wide a range of scale of farm as the acreages would indicate. That is, a 240-acre farm is not 50 percent larger than a 160-acre farm either in terms of capital investment, labor applied, or annual inputs. Neither is a 320-acre farm twice as large as a 160-acre farm, all resources considered. Within the limited range studied, however, it appears that once an efficient 160-acre organization is achieved, the returns to increases in scale are of a constant nature. In the area studied, 160-acre farms can and do operate on nearly as efficient a basis as 240-acre or 320-acre farms. That net incomes on many 160-acre farms were inadequate in 1950 is obvious, also that operators of 240-acre and 320-acre farms achieved higher net incomes on the average. However, our analysis appears to indicate that increases in size of farm as measured in acres will be accompanied by less than proportionate increases in income. The 160-acre operator who has the choice of allocating limited capital funds to buy an additional 80 acres or to apply additional inputs to his present acreage, may find the second alternative more desirable.

Our economic literature is abundant with the notion that for any one manager there is a most efficient size of farm. One man might manage and operate a 240-acre farm most efficiently. A second might be most efficient with a 160-acre farm, but would experience less success on a 320-acre farm. If this is true, we must conclude that farms of the three sizes can be operated, side by side, under the farming conditions of the study area, with operators of each size achieving a reasonable degree of efficiency within limits of their management capacity.

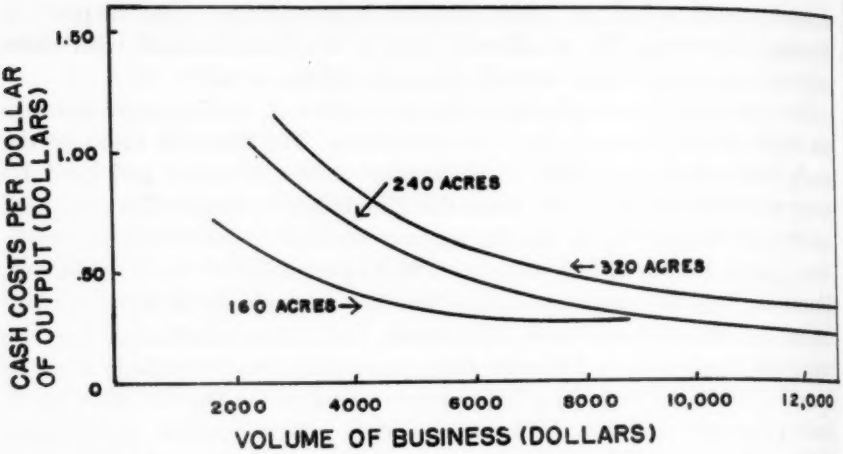

FIG. 4. RELATIONSHIP BETWEEN CASH COSTS PER DOLLAR OF OUTPUT AND VOLUME OF BUSINESS ON THREE SIZES OF FARMS IN NORTHEASTERN NEBRASKA, 1950.

Cash Costs

Certain errors in valuation of resources in the previous analysis have been noted. To check our conclusions, and because farmers probably are more cognizant of cash costs and cash income levels than of total costs and total income levels, we shall examine the effect of volume of business on cash costs per unit of output on the three sizes of farms. This relationship is illustrated in Figure 4. We conclude that in terms of cash expenditures and returns (including inventory increases) the sample farmers were operating profitably for the most part in 1950.

A substitution of cash inputs for non-cash inputs (e.g. labor) is evident on the larger farms. Examination of the data revealed that on these farms expenditures for hired labor, custom work, concentrate feeds, and fertilizer were more than proportional to acreage. On the other hand, they spent less per acre for fuel, oil, and building repairs.

NONFARM EMPLOYMENT INFORMATION FOR RURAL PEOPLE*

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> For if a man had sufficient ability to know everything about the market for his labour, he would have too much to remain long in a low grade.
> —ALFRED MARSHALL

I. *Background and Assumptions*

THE process of disseminating information has long been recognized as important to the efficient marketing of goods produced on farms. Obviously, adequate information is equally important to intelligent marketing and utilization of factors of production, including labor. This paper is addressed to the subject of information pertaining to the market for rural labor in nonfarm industries.

The objectives of this study embrace somewhat more than those of pure allocative efficiency. A primary objective is to examine possibilities of creating better opportunities for rural people to obtain a higher level of living through farm and nonfarm work and thus to share more fully in the fruits of economic progress. But real opportunities are those which migrants, who create possibilities for resource recombination on farms, are able to accept in full knowledge of their ultimate total consequences. Misrepresentation and coercion as means of reallocating rural labor are ruled out by assumption.

In terms of economic concepts, the objective of supplying more perfect employment information is to bring the supply curves of rural labor in farm and nonfarm uses into closer correspondence, to narrow the real wage gap between urban and farm alternatives.[1]

* Based on research conducted at the University of Chicago, Department of Economics, under a grant from Rockefeller Foundation. Results of the entire study were presented as a Ph.D. thesis at the University of Wisconsin. This paper represents a refinement and extension of some of the ideas developed therein.

** Assistance of staff people at the University of Chicago, University of Florida, University of Tennessee, and University of Wisconsin is gratefully acknowledged. Particularly Professors K. H. Parsons, Erven J. Long, D. Gale Johnson and Theodore W. Schultz have contributed to the development of these ideas. However, sole responsibility for the paper is assumed by the writer.

[1] This is not necessarily a complete statement of the objectives of an over-all migration policy. Information, as such, is capable of nothing more; labor capacity for these purposes must be considered as given. Even with perfect mobility of labor—that is equalizing the marginal value productivities of rural labor in agriculture and nonagriculture—returns to labor in agriculture would possibly be lower than returns to labor in nonagriculture. Specialized training in one occupation or unequal degrees of training in general productive skills such as English or mathematics could create unequal earnings even with complete mobility.

Most writers have taken a rather optimistic view of the possibilities of increasing farm-nonfarm migration by improving information services. For example, Dr. D. Gale Johnson states, "The first step that should be taken in any attempt to facilitate shifts in manpower is an expansion of the available sources of information."[2] Like several others, he assumes that information is a limitational factor in migration. This study subjects this hypothesis to empirical test and elaborates the assumptions upon which its affirmation depends.

The empirical medium in which this hypothesis will be examined is a case study of the experiences of migrants to Indianapolis, Indiana. The interrelationships noted are intended to suggest strategic factors in the broad problem of farm-nonfarm migration; but to determine the extent to which these relationships are either general or particular to the area studied will require other evidence.[3,4]

II. *The Broad Look*

In determining the effectiveness of more employment information, it is important to know if most people are obtaining adequate information through existing media. However, even, as later analysis will show, the

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Note that elasticity of the supply curves may be altered in addition to their height. However, this is not relevant under assumptions of pure competition. Such assumptions are usually applicable in large urban centers where many firms compete for the supply of labor. In small communities it is more common to encounter oligopsonistic or monopsonistic labor markets. Under such conditions a change in slope of the market supply curve for rural labor at any given point would change the height of the marginal labor cost curve facing each labor-using firm. Therefore, the market equilibrium price and quantity would be affected by the elasticity of supply, as well as the height of the schedule, in an oligopolized market.

[2] D. Gale Johnson, "Policies and Procedures to Facilitate Desirable Shifts of Manpower," *Journal of Farm Economics,* Vol. XXXIII (1951), p. 728.

[3] "If a case as evidential material is but a sample area or a sample group of units of observation, it may be analyzed in such a way as to offer evidence of relationships which have instrumental or suggestive usefulness." Leonard H. Salter, *A Critical Review of Research in Land Economics,* University of Minnesota Press, 1948, p. 71.

[4] Data were obtained by a system of random block sampling and petain to male migrants then located in Indianapolis who had lived on a farm after January 1, 1940. Interviews were taken in 1952. It may be argued that selectivity was involved since many, and disproportionate numbers in different groups, may have returned to rural areas after a short period of urban employment. The fact (to be noted in detail later) that distinct differences in characteristics still persisted among the groups distinguished probably indicates that this is not a serious weakness of the data. If no differences had appeared, a much stronger case could have been made for the theory that real differences had been obscured by this selectivity, assuming that the characteristics under study were related to, or correlated with, the tendency to return to rural areas. The three primary migrant groups distinguished for purposes of sampling and analysis were: Northern white, Southern white (Kentucky and southward), and Negroes.

fact that people have little information does not guarantee that migration would be increased if adequate information were supplied.

It is difficult to establish from data regarding people who have already migrated how much information comes to the attention of rural people. For example, most of the migrants (101 out of 130 reporting)[5] in Indianapolis reported having some information about employment conditions before arriving there (Table 1), suggesting that most farm people had access to such information. On the other hand, if such information is

TABLE 1. SOURCES OF URBAN LABOR MARKET INFORMATION RECEIVED PRIOR TO MIGRATION TO INDIANAPOLIS BY MIGRANT GROUP

	Migrant Group						Total	
	Negro		Southern White		Northern White			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All relatives or friends	28	78	37	88	13	48	78	74
From immediate family[a]	11	—	11	—	4	—	26	—
From other relatives	10	—	19	—	6	—	35	—
From friends	7	—	7	—	3	—	17	—
All formal media	2	5	3	7	4	15	9	9
From newspapers	2	—	2	—	2	—	6	—
From U. S. Employment Service	—	—	1	—	2	—	3	—
Rumors[b] and miscellaneous	6	17	2	5	10	37	18	17
Total sources reported	36	100	42[c]	100	27[d]	100	105	100
Reporting no information	13	—	10	—	6	—	29	—
Source not specified	2	—	9	—	4	—	15	—
Not seeking work	4	—	—	—	5	—	9	—
Part-time farmer—continued same job	—	—	—	—	3	—	3	—

[a] Brothers, sisters, sons, daughters, father or mother of respondent or of his wife.
[b] Any indirect source of information about conditions in Indianapolis.
[c] Three reported multiple sources.
[d] One reported multiple sources.

effective in encouraging migration, it is possible that these people represented merely that minority segment of the population who did possess such information.

Clearly the data do not permit very precise statements regarding the amount of information available to farm people in general. However, it is important to note that among the various classes of migrants studied there were distinct differences in sources and adequacy of employment information. Most of these differences could be anticipated by reflecting upon the limitations of the various possible media and the area from which each migrant class or group originated.

[5] Total after allowing for four migrants with two sources reported.

For fairly obvious reasons the intensity of saturation of an area by information disseminated through newspapers, radio, employment services, and other conventional media will tend to vary inversely with distance from the employment center. Consequently, informal means, such as personal contacts with friends and relatives in the city, and the like, are often the only means of communication available between remote areas and employment centers. As a result, we may expect that people in distant areas will tend to have less adequate information than those in nearby areas and that such information as they do have will come mainly from friends and relatives.

The data tend to support these hypotheses. Of the Indianapolis Northern white migrants studied, most of whom originated within a radius of 100 miles of the city, only about half of those with some information received it from friends or relatives. In contrast, 78 percent of the Negro migrants and 88 percent of the white migrants from the South received their information from friends and relatives. Most of the Negroes came from Mississippi; the Southern whites from Southern Kentucky and Tennessee. These Southern areas are, of course, well beyond the usual range of most organized media disseminating information from the Indianapolis area.

In the two migrant groups relying predominately on information from friends and relatives (Negroes and Southern whites) the information received was much less specific regarding the nature and availability of employment than the information received by the group relying least on this source (Northern whites). Over two-fifths of the Northern whites reported that they knew that a particular job or a particular kind of job was available to them before moving to Indianapolis. In comparison, less than a tenth of the Negroes and Southern whites had this degree of assurance of available employment (Table 2).

Those who reported nonspecific information also tended to report having a pessimistic attitude prior to migration regarding their ability quickly to locate employment for which they could qualify. This was especially true of Negroes, 76 percent of whom reported that employment was easier to secure than they had anticipated, while only 11 percent encountered more difficulty than they had anticipated. Fifty-four percent of the Southern whites reported employment to be more easily secured than they had expected while only 8 percent reported the opposite experience. Northern whites in only 32 percent of the cases reported that employment was more easily obtained than expected, while 23 percent reported more difficulty in securing employment than expected.

The period during which these people made their decisions to migrate was one of almost continuous full employment. The Southern migrants

actually reported very little difficulty in acquiring their first job. In spite of this fact they feared inability to secure employment quickly. In view of this, it would appear that specific assurance of employment to potential migrants through some better organized information and placement system will be required if this barrier to mobility is to be overcome.

It can be argued, of course, that there has been a substantial outpouring of population over a long period from areas that are now heavily

TABLE 2. SPECIFICITY OF EMPLOYMENT INFORMATION RECEIVED PRIOR TO MIGRATION TO INDIANAPOLIS, BY MIGRANT GROUPS[a]

Specificity	Migrant Group						Total	
	Negroes		Southern Whites		Northern Whites			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1. Very specific; definite information that a specific job or kind of job was available to migrant	4(1)	7	5	9	19(3)	43	28(4)	18
2. Fairly specific; reasonable assurance of some kind of job at a particular place but no particular job	8(8)	15	19(7)	33	5(1)	11	32(16)	20
3. Not specific; general information that there was demand for labor, but no particular place or job	26(1)	47	23(1)	39	9(1)	21	58(3)	37
4. No information	13	24	10	17	6	14	29	18
5. Not looking for work	4	7	—	—	5	11	9	6
6. No report	—	—	1	2	—	—	1	1
7. Total	55	100	58	100	44	100	157	100

[a] The specific wording of the question, which interviewers were instructed to follow exactly, was: "Did you know that there would be a particular job for you or did you have just a general idea that you could get work?" The interviewers were instructed to record verbatim the response given so that a standard classification could be made in the office. This instruction was not followed in all cases. Numbers shown in parentheses indicate the number of answers coded by the interviewer that were not accompanied by a meaningful recorded verbatim response. Numbers not in parentheses are totals.

overpopulated. Hence, most of the people in these areas will have kinship and friendship ties in nonfarm areas that constitute a potential source of reliable employment information. However, the mere fact of substantial previous outmigration from an area does not necessarily mean that there is an adequate channel of communication established between this area and urban centers offering maximum employment opportunities. As Johnson[6] has stated and as Census data and other surveys show, most off-farm migration is to relatively nearby destinations, mostly within the

[6] Johnson, *op. cit.*

same state (80.3 percent between April 1948 and April 1949).[7] And only about one-sixth of the migrants interviewed in Indianapolis had any intervening employment after leaving the farm and prior to arrival in Indianapolis, indicating that few of those who move to nearby areas subsequently move on to distant cities. Thus, unless the previous migration out of the areas has coincided with substantial *direct* migration to areas with maximum opportunities, the fact of previous out-migration does not mean that the problem of employment information has been solved. It merely means that contacts have ben established in some nonfarm community, a community perhaps incapable of providing adequate employment opportunities.[8]

Perhaps equally important is the fact that a contact with a friend or relative in a particular major industrial center outside the labor surplus region does not necessarily mean that this particular city provides the most numerous and lucrative opportunities available at any given time. For example, during the 1940-1950 decade Los Angeles experienced a very rapid expansion of industrial activity while the Minneapolis area expanded at a much slower rate. It was found in the course of the present study that correlated with these differences in rates of growth were distinct differences in beginning wages of white migrants. Starting wages of white migrants to the Minneapolis-St. Paul area between 1940 and 1950 averaged about 13 percent lower than wages of migrants to the other cities covered in a Bureau of Census survey. They were 29 percent lower than wages of Indianapolis Northern whites during a roughly comparable period.[9] (Indianapolis data were gathered at a different time using a roughly comparable interview schedule.)

The fact that such personal connections are not uncommonly limited to one or two large urban areas is clearly illustrated by the following facts: Although nearly all migrants to Indianapolis had close friends or relatives in the city before they migrated there, only 62 percent of the Negroes, 44 percent of the Southern whites and 47 percent of the North-

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[7] Bureau of the Census, *Current Population Reports*, Series P-20, No. 28, Table 5, p. 9.

[8] Direct migration is defined as a movement of population from farms toward Northern urban areas by means of single moves direct from farms to large cities.

[9] Wage earnings deflated to a comparable base period using the United States index of hourly earnings, gross and exclusive of overtime, of production workers in manufacturing industries. Source: *The Monthly Labor Review*, United States Department of Labor, Table C-4. Basic data extracted from a survey sponsored in several large cities in cooperation with the Department of the Air Force and local agencies by the Bureau of the Census and analyzed by the writer. Reference: Eldon D. Smith, *Migration and Adjustment Experiences of Rural Migrant Workers in Indianapolis*, unpublished Ph.D. thesis, University of Wisconsin, 1953 pp. 258-260, Figure 18.

ern whites had any friends or relatives in other large cities. In addition, a Tennessee study showed that long distance migration out of a West Tennessee county concentrated in three large industrial centers of the Midwest.[10] Finally, it would take a very substantial number of friends and relatives to supply comprehensive employment information about even one major industrial center.

In view of these factors, there is apparent need for facilities to provide employment information necessary (1) for intelligent decisions regarding farm and nonfarm employment and (2) for co-ordinate decisions regarding the nonfarm area that would provide the most favorable employment opportunities. Both require information regarding the ever-changing pattern of opportunities among the various employment areas. Unless and until industrial development within overpopulated rural areas or nearby nonfarm centers becomes sufficient to absorb the excess rural population, the process for marketing our rural labor in more distant urban centers must be improved if the problem of pressure of rural population on local resources is to be solved. This will involve improvement of informational services.

III. *Qualifications and Related Considerations*

Need for information related to acceptability of opportunities

The assumption implicit in the foregoing discussion is that nonfarm opportunities are acceptable alternatives of employment to farm people. Given this assumption, the problem becomes one of providing relevant information about urban opportunities to the appropriate underemployed and underpaid rural people. Obviously the acceptability of alternative employment may embrace more than wages and perquisites.[11]

Accepting urban employment ordinarily involves, in addition to a change to a new type of job, a geographical shift in area of residence.

[10] Joe A. Martin, *Impact of Industrialization upon Agriculture—A Study of Off-Farm Migration and Agricultural Development in Weakley County, Tennessee,* Ph.D. thesis, University of Minnesota, 1955.

[11] Of course, it is true that we have at present only crude information of an aggregative type regarding the earning power alternatives of rural people. Some light is thrown on this subject by a study by D. Gale Johnson, "Comparability of labor Capacities of Farm and Nonfarm Labor," *American Economic Review,* Vol. LXIII, No. 3, June 1953, pp. 297-313. These very gross, aggregative results had to be seriously qualified. The data also abstract from the variations among groups in agriculture, except insofar as the variations may be attributed to differences in age and sex. Our data showed wide variability among individuals of comparable background and experience. And, of course, the relevant information to the individual is not what people of his general background can earn but what *he* can earn with his particular unique combination of training, experience, personality, and native attributes.

When this is true, the array of possible consequences of the choice is broadened and with it the range of relevant considerations in making the choice. The conditions of living, both social and material, to which the worker and his family must subject themselves as a consequence of accepting an urban job are as important a part of such a decision as are wages, hours and working conditions. It is the *total* evaluation that is important. Therefore, the way in which attitudes of prospective migrants toward life in the city are shaped is a matter of considerable importance.

As was pointed out before, most information reaching prospective migrants some distance away comes from friends and relatives who presumably communicate their reactions and attitudes toward their urban experience to these prospective migrants. Thus, the experiences of one migrant color the picture that potential migrants obtain of what their experience will probably be like.

Unfortunately the fact that earnings are usually improved substantially does not always mean that the total experience has been satisfying or enjoyable. Nearly one-half (44 percent) of Indianapolis migrants indicated that they were dissatisfied to the extent that they were hoping or actively planning to return to farming.[12] Reportedly many more, particularly Southern whites, leave and return to their home areas after only a brief and unsatisfactory experience. Therefore, it seems plausible to believe that a large proportion of potential migrants receive adverse reports about urban life from friends and relatives who have previously migrated.

Moreover, these adverse reports apparently exert a powerful influence on the decisions of potenial migrants. Only five migrants out of 144 reporting had migrated to Indianapolis in the face of advice against such a move from friends and relatives in Indianapolis.

This suggests that the experiences of a migrant not only affect him, but, through the attitudes that he expresses to potenial migrants, these experiences may also determine whether or not other people migrate to nonfarm employment. The possibility of stimulating continued migration through improved information services is obviously questionable unless the experience of urban employment and urban life is such that it can be accepted in full knowledge of its consequences. Indeed, migration would probably be socially undesirable if its consequences were so personally calamitous as to result in return migration, or the desire to return to farm life.

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[12] Other evidence presented later further substantiates the hypothesis that many migrants, particularly Southern whites, are dissatisfied with urban life because of inability to adjust satisfactorily to urban living in general and to the customs and habits of Northern urban people.

Satisfaction with urban opportunities related to social adaptability to urban life

Satisfaction of individuals or groups with their status in a new occupation, a new community, and a new cultural matrix depends on their ability to adjust their modes of behavior harmoniously to patterns acceptable in their new social situation. The smaller the initial differences, and the more adaptable the habits, customs, and values of these people, the simpler the problem will be for them.

Obviously the difference in day-to-day demands of urban existence and rural existence have resulted in differences in the customs and habits of rural and urban communities. The more individualistic habits of farm people, and their greater emphasis on hunting, fishing and other noncommercial forms of recreation are familiar. Within the more heavily industrialized areas of the North, considerable interpenetration of rural and urban cultures has occurred through improved transportation and commercial and recreational activities. This has resulted in a great deal of similarity of customs and mores in country and city. Because of a much lesser degree of such industrial development in the South, this interpenetration is probably less complete, and, in addition, the cultural differences between the rural areas of the South and the urban areas of the North are magnified by the interregional (North-South) cultural distinction.

In view of this, one might expect that the change to life in a Northern urban community would require somewhat fewer adaptations for the Northern white migrant than for the Southern white. The Southern white migrant must not only adjust to a new job and a new set of housing accommodations; he must adapt himself to a new set of customs, a markedly different "kind of people."

The South, unlike the Midwest, was settled early by people of essentially homogeneous Anglo-Saxon culture. The waves of settlers of Dutch, German, Scandinavian, French and various other nationality origins that swept across the Midwest bypassed the states south of the Ohio River almost completely. The rural areas as well as the urban areas of the North are to this day a mosaic of nationality groups. Thus the experience of associating with people of dissimilar background, religion, habits, etc., is simply part of the process of growing up in rural areas of the Midwest and Northeast. On the other hand, in the South, particularly in its rural areas, there has been little opportunity for such experiences simply because the later immigration from continental Europe did not penetrate the region. The necessity of adapting to cultural heterogeneity and a changing cultural complex may have developed more highly in the Midwesterner than in the Southern farmer the capacity for adapting to unfamiliar social situations.

Summarizing, as a result of experiences of the past that have been built into his culture, and over which he has had no control, the Midwestern farmer migrating to a Northern urban center might be expected (1) to have a smaller adjustment to make and (2) to have a more highly developed capacity to make the necessary adjustment than does the Southern farmer.[13] It must be emphasized, however, that if this hypothesis is valid, it constitutes no indictment of the character of Southern farm people. It merely means that these people who migrate from Southern farms to Northern urban areas face somewhat more difficult problems than do farmers from other areas, and may, therefore, need other types of preparation and assistance in addition to employment information.

In general the hypothesis is substantiated by the study of Indianapolis migrants. Northern whites appear to be rapidly assimilated into the urban culture and soon lose their identity as migrants. Distinctive speech habits and other cultural factors identifying them as migrants are generally lacking. They make new friends more rapidly than do Southern whites and their capacity for making new friends among urban people and people from other regions also appears to be somewhat superior. Northern white migrants were not found grouped together in identifiable communities as were the Southern whites. Reports of employers indicate that they are stable workers with no unusual rate of turnover, suggesting that return migration is not very important and that they have been able to adjust satisfactorily. They are reportedly quite easily trained to new skills, particularly mechanical skills. The fact that they are favorably regarded as workers is evidenced also by the fact that the beginning wages of Northern whites in Indianapolis are significantly higher than those of Southern whites even after allowing for differences in educational preparation.

In contrast, reports of local people indicate a figurative ingestion of Southern white migrants but a lack of digestion and assimilation. This is precisely what we might expect of a people whose customs have developed in a relatively homogeneous rural culture, distinctly different from the Northern urban culture. They are immersed in a new culture replete with subcultures composed of nationality groups, a situation that stands in sharp contrast with their backgrounds in the culturally homogeneous

[13] This point is well illustrated by the fact that only one of the Southern white migrants had a definitely non-Anglo-Saxon name, while twelve of the Northern whites had definitely non-Anglo-Saxon names and another five were doubtful, but probably Anglicized non-Anglo-Saxon. We here assume that no differences are attributable to educational attainment. Analysis of this factor showed that within the narrow range of observations education was not significantly related to adjustment. A differently oriented educational program, however, might produce different results. See my thesis (*op. cit.*) pp. 165-173.

South. Thus, the habits and values they have acquired in this situation make adjustment difficult, slow and incomplete. Their close friends tend to be old friends in the home area or old friends who have moved to Indianapolis. Fellow migrant Southerners tend to be disproportionately represented among friends acquired since migration, relative to the proportion of Southerners in the Indianapolis population. Their failure to adjust to urban ways has made them into a minority group stereotyped with characteristics unacceptable to the urban whites.

Whether this stereotype fits these people is open to serious question, but for the purposes here this question is not in point. It is not what the Southern whites are like but what other people think that they are like that determines the way other people behave toward them. They are, in fact, not well accepted by the urban people and tend to congregate in identifiable cultural cells in the poorer residential areas.

Reportedly many of these Southern white migrants return to their home areas after a short period of urban life. Partly because many return to the farm, employers often regard them as poor employment risks for jobs requiring any substantial training period and consider them inferior workers on even unskilled jobs. This is reflected in lower beginning wages than those received by the Northern whites.[14]

Much could be said about the history of the American Negro, about the uprooting of Negroes from African tribal culture, the demands of slavery and the propertyless condition of most of the freedmen after the Civil War, which meant hired laborer or sharecropper status for most of them. Undoubtedly these events left a deep mark on Negro culture, perhaps cultivating a propensity to conformity and getting along. But the most significant feature of American Negro history from our standpoint is probably the fact that the Negro culture of the Northern urban centers was "imported" from the South. For example, more than 53 percent of the 1940 nonwhite males in Indianapolis were born in the South, while only 10 percent of the white population was born in the South.[15] Since the Negro's sphere of association is largely circumscribed by the racial distinction, the cultural environment to which he must adjust in North-

[14] In firms requiring highly specialized skills, trainability as well as present skill levels will provide bases for rational employment policy, including initial wages paid. Discrimination against one group on this basis would mean a larger supply of labor in unskilled occupations. If the groups were large, wages would be forced down. Several employers indicated a policy of discrimination against Southern whites due to a reputation of high turnover; they reported that high turnover made training economically unfeasible.

[15] This includes all ages. If only adults were considered the proportion of nonwhites born in the South would be considerably higher. Also many, probably a vast majority of those born in the North, were children of migrants who were born in the South. No comparable 1950 Census data are available.

ern cities is essentially similar to the one in which his values and attitudes were formed. Therefore, we would expect that it would be much simpler for the Negro to adapt to urban living simply because there is a smaller adaptation to be made.

Both the reported observations of local Indianapolis people and reported friendship ties of Negro migrants are indicative of an extremely rapid and complete adjustment of Negro migrants to the life of this Northern urban center. So far as can be ascertained, no important stereotype distinguishes Negro migrants from other Negroes. Only in their work attitudes are there reports of any persistent and noticeable differences between native urban Negroes and migrant Negroes. In this respect migrant Negroes tend to be preferred. They appear to intermingle with their fellow Negroes without regard to region of origin and without regard to whether they are fellow farm migrants or native urbanites. Participation in both formal and informal social activities was reported to be about the same as was experienced prior to migration. Insofar as occupational adjustment is concerned, most Negroes either preferred their present job to farm work or had no definite preference. Almost three-fourths of the Negro migrants expressed definite intentions of staying in Indianapolis or some other large city. In general, then, the adjustment experiences of Negro migrants are relatively satisfactory in almost every major regard. Due, in part, to the fact that the urban Negro culture is essentially a transplanted Southern Negro culture, the increased earnings of urban occupations are bought at little cost in terms of the intangible factors associated with migration and adjustment to a new social and economic environment.

The differences in adjustment experiences have consequences for the productivity of labor itself in addition to their effects on mobility. The instability of the Indianapolis Southern white migrants in particular, resulting from the difficulties encountered in adjusting to the abrupt change to Northern urban living, makes them less valuable as employees than otherwise would be the case. In fact, there is no evidence that the average starting wage of Southern whites covered in this study was any higher than that of Negroes despite the fact that occupational segregation is by no means a thing of the past in Indianapolis. These wages are probably a fairly reliable index of the estimate Indianapolis employers make of their relative marginal contribution. At least it corresponds fairly well with the stated evaluations of several employers who were interviewed in the course of the study. This means that their opportunities are affected by their ability to adjust socially.

To summarize, if potential migrants are ill prepared for the social and occupational experience of urban life, it is unlikely that merely providing

information regarding the types of jobs that are available will materially affect migration. Whether we like it or not, the attitudes of migrants arising out of their migration and adjustment experiences will filter back to their home areas and influence the decisions of other potential migrants. In other words, the effectiveness of information services presupposes that some other problems are either absent or capable of solution. We should look carefully, when judging the need for better informational services, at the type of people with which we are dealing, their peculiar cultural traits and their adaptability to the cultural complex of the area in which they must live in virtue of accepting the available employment. The evidence suggests that for some fairly large groups of underemployed rural people the baffling problem of how to prepare them for urban life must be solved before informational services can be very effective.

Other complementary factors related to acceptability of opportunities

There are, of course, several other possible barriers to mobility that might be examined such as financing the move, problems of acquiring housing, etc. In retrospect, Indianapolis migrants tended to feel that these problems had actually been of no great significance, but that they had loomed importantly in their anticipations prior to migration. And, as noted before, it is these anticipations that form the basis of decisions.

Moreover, data from this and from other studies show that friends and relatives often provide temporary living quarters (105 out of 148) or assistance in acquiring permanent housing (87 out of 137) and other services. One wonders if information alone would be sufficient to stimulate migration if these services were not available, particularly when financial resources of potential migrants are very meagre. Would these have been insurmountable problems if the assistance of friends and relatives had not been available?

IV. *Relevance of Facts Communicated Related to Effectiveness of More Information*

If the type of community, availability of housing, etc., have an important bearing on the total acceptability of the change to an urban occupation, is it not reasonable to expect that people making such a decision might require information relating to these various "noneconomic" matters? Would it not be reasonable for people to continue to rely on information from friends and relatives because they thereby have a source of information (of good or poor quality) about *whatever* matters are judged to be important to the outcome of the choice? Since information facilities now in existence are primarily used by people living in or

near the area of employment, it is not surprising that the wages, hours, and fringe benefits aspects are normally available information, while the aspects pertaining to living conditions are not. To migrants the living-conditions aspects may be viewed as more important.

The rural-urban migration process and the choice pertaining thereto is unique and requires (if the above hypothesis is valid) a unique approach, an approach now lacking in public or commercial media. And developing the proper approach, i.e., ascertaining the appropriate types of information to be communicated, is in no sense a simple matter.

V. *Summary*

1. When considerable distances are involved in rural-urban migration, special problems are created that are not ordinarily dealt with by conventional employment information media. As a result these media do not adequately meet the requirements of the farm-nonfarm migration process. Special means or adaptations designed specifically to meet these requirements of long distance migration from rural areas are needed.

2. Evidence indicates that lack of specific information results in doubts and fears that may contribute to immobility.

3. The success of improved information services will be limited unless the following conditions are met:

   a. The distance between the rural area to be served and the sources of employment is substantial. People in areas near large metropolitan centers will probably have relatively good information from existing sources.

   b. The people are socially equipped to meet the problems of adjustment to new occupations and new surroundings successfully. If unable to do so they will probably not accept urban employment, or accept it only for a short time and frustrate further efforts by advising their friends in the home area against migrating.

   c. The initial problems of migrating and getting established are capable of solution with the means available to the migrant. If not available, facilities designed to aid in this process may be required before information services can be effective.

   d. The information disseminated fits the broader social needs of people whose change of occupation coincides with a change in locus of living and type of environment.

   e. There is a prospect of a worth-while increase in real earnings. For some migrants the attainable increase is limited by background and training for urban employment and living.

4. If Indianapolis migrants are representative of migrants to other Northern urban areas, information supplied to areas with large numbers

of underemployed Negroes is likely to result in substantially more migration than if supplied to either Northern agricultural areas, or areas of predominantly white population in the South, because their increased earnings are bought at little sacrifice in terms of the intangible costs involved in migration and adjustment.

At a more general methodological level these results indicate that a successful attack on the problem of rural poverty will, to the extent that migration to large Northern cities is involved, require research that transcends the traditional boundaries of economics. Schemes based solely on analyses of the traditional types are likely to yield only little improvement because they will fail to encompass the full range of relevant issues, i.e., the full range relevant to the experiences of migrants who, in the last analysis, must make the decisions of whether to migrate or to stay in agriculture. Other social disciplines could unquestionably contribute much to the understanding of migration. Economists, it appears, must either take the initiative in building needed interdisciplinary connective tissue or risk letting some extremely important problems go unsolved.

ORIGINS AND RELATION TO AGRICULTURE OF INDUSTRIAL WORKERS IN KINGSPORT, TENNESSEE

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IF THE introduction of industry into rural areas is to alleviate rural poverty, the new plants must draw many of their laborers from the farm people. This project examines the labor supply of two major manufacturing plants in Kingsport, Tennessee, a city of some 35,000 people in Sullivan County, which since the 1920's has seen rapid industrial growth in an area up to then predominantly agricultural. Figure 1.

To judge how effective these plants have been in drawing workers from nearby farms, we have asked: Where did the workers come from and what was their previous work experience or training? In this connection, we have inquired (a) whether there are signs that, after drawing their workers from the farm in the early years, the plants have become part of a maturing industrial community and are today hiring primarily people already in town, or (b) whether the plants have continued to obtain many of their new workers from the farm. Secondly, from the viewpoint of the practicality of a program of rural industrialization we have asked: Who make better workers, people of farm or nonfarm backgrounds?

The study is based on a sample of 700 hourly workers (550 men and 150 women) drawn from the active and inactive personnel files of the two companies. Data on women have been kept separate and, unless otherwise specified, our statistics apply to men.

I. *Origins and Previous Experience*

Our study shows little or no significant change over time in the distance from Kingsport or in the distribution among the surrounding counties of the origins of workers as indicated by their places of birth or by the location of their grammar schools.[1] Figure 2 shows a rather hypothetical distribution of origins according to distance. The sample gives us no statistical ground to reject the distribution, however, as the

* This note reports the results of the author's research during the summer of 1955, made possible by a grant from the Social Science Research Council under its Undergraduate Research Stipend Program. Professors William H. Nicholls and E. J. Eberling directed the project. The author wishes to acknowledge and express his appreciation for the friendly cooperation of the firms, which wish to remain anonymous, from whose records this study was made.

[1] Throughout this paper "significant" is used in a statistical sense: the difference of two measures observed in the sample is significant only if, supposing the true measures in the parent population were equal, so great a difference would occur due to chance in drawing the sample less than five times in a hundred.

FIG. 1. MAP OF KINGSPORT AREA

pattern we should have found in a study of all the workers hired in any years since the plants opened. The origins according to county of the presently active employees, and those of all women, do not differ significantly from the following pattern:

County	*% originating in*
Sullivan	26
Scott	22
Hawkins	18
Washington	9
Greene	6
Other	19

The residences of the workers when hired have shown significant changes through the years. See Figure 3. Since labor close to the town was hired before the pull on the farm population was felt, these residencies showed a high geographical concentration in the early years, 1922-36. Then during a middle period, 1941-43, a time of rapid growth for the plants, men came from greater distances, thus probably indicating a much stronger effect of the plants on the surrounding farm population. The contraction of the labor-supply area since 1947, however, indicates that this effect was lessening as Kingsport matured as an industrial community. Likewise there have been significant shifts in the distribution of

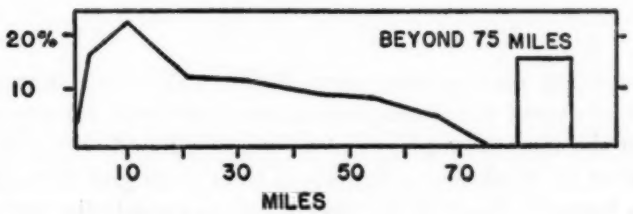

FIG. 2. DISTANCE OF ORIGINS FROM PLANTS

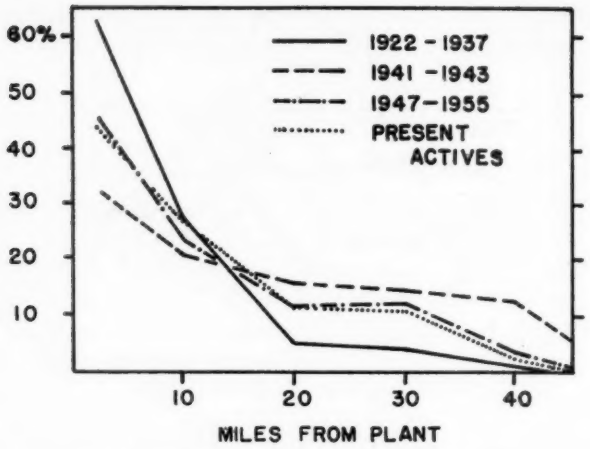

FIG. 3. DISTANCE OF RESIDENCE WHEN HIRED

residences when hired among the counties. The percentage of workers coming from Sullivan County followed the same path as the concentration by distance. Scott County carries much of the compensating change in percentage:

Residences When Hired, by County

County	*1922-36*	*1941-43*	*1947-55*
Sullivan	79%	38%	52%
Hawkins	3	17	18
Scott	7	21	11
Washington	6	10	7
Greene	1	7	5
Other counties	4	7	7

Residences When Hired, by Distance

Distance	*1922-36*	*1937-40*	*1941-43*	*1944-46*	*1947-55*
0-5 miles	63%	43%	32%	45%	46%
5-15	27	31	21	22	24
15-25	5	10	16	12	12
25-35	4	8	15	15	12
35-45	1	4	11	5	1
over 45	0	4	5	1	5
Workers in sample	75	49	121	109	81

In recent years, each county except Sullivan and the "Other Counties" item has had almost the same percentage of newly hired workers residing in it at the time of employment as had originated there. The greater concentration of residences when hired than of origins thus appears to have been brought about by the workers from outside the area skipping

over the immediately neighboring counties (Hawkins, Scott, Washington, and Greene) into Sullivan.

There has been a slight further contraction in residence among the active employees since employment. The shift indicates that about one-third of the workers originally residing more than fifteen miles from the plant—or about a tenth of all employees—have, on net, moved to the city. (About a five-mile radius about Kingsport is included as city.) Thus, the direct effect of the plants in getting workers to move from the farm must have been rather small. But the large gap between the "residence when hired" line and the "origin" line in Figure 4 may show an indirect effect of the plant. Workers came from the farm to the city to take jobs whose

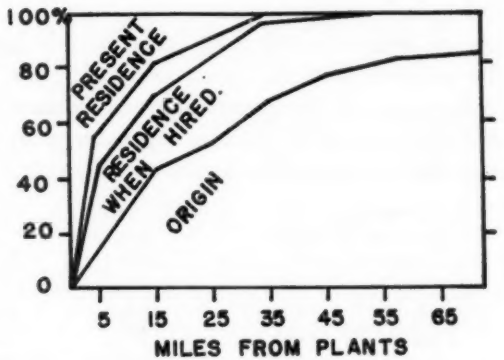

FIG. 4. RESIDENCE OF ACTIVE EMPLOYEES (CUMULATIVE PERCENTAGES)

previous holders had gone to work for large plants. Later these same workers from the farm also got jobs in these large plants.

Roughly half the workers in these plants were reared on the farm, although the exact percentage has shown significant changes. The percentage was about 56% from 1922 to 1941. It rose to 68% during the war years but dropped to about its former level for 1947-50. Since 1950, the percentage has fallen further to around 39%, lending support to the maturing-industry thesis.[2]

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[2] A person was considered having been reared on the farm if he either listed having farmed or said that his father had farmed. A questionnaire study of a much smaller though older Kingsport company showed that about 14% more workers said they had been raised on a farm than said that they had ever farmed or that their father was a farmer. Thus, the percentages for farm background given above should perhaps all be eight or nine points higher. At this smaller plant, where the caliber of worker required is not as high as at the large ones, a much greater proportion (79%) of the workers were raised on the farm. This difference would seem to support the indirect-effect argument of the previous paragraph.

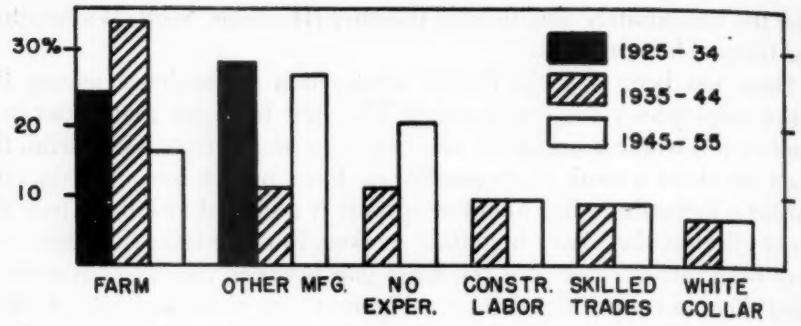

FIG. 5. PROPORTION OF WORKERS FROM PRINCIPAL LAST PREVIOUS JOB (1925-34: Sample too small to give reliable results except where shown.)

The percentage of workers with farm backgrounds has varied significantly among the workers from different counties. These variations may be a result of differences in the percentages of farmers in the counties and of county differences in farm income. A greater proportion of farmers were found among workers from low-farm-income counties:

County of residence when hired	*Percentage with farm background**		*Median rural farm income*	*Percentage in agriculture*	
	1935-44	*1945-55*	*1949*	*1940*	*1950*
Sullivan	(55%)	39%	$1679	14.7%	8.5%
Scott	88	87	999	64.7	43.0
Greene	(76)	(66)	1174	63.4	48.0
Washington	43	(69)	1374	22.5	17.3
Hawkins	85	63	953	60.3	42.2

* The percentages in parentheses do not differ significantly (in a statistical sense) from either the next higher or next lower unenclosed term.

The percentage of workers coming directly from the farm rose between the 1925-34 and 1935-44 periods, but declined by half during 1945-55. See Figure 5. Conversely, the percentage coming from other industrial jobs was high, then fell, then rose again. These changing percentages further support the proposition that industry's effect on the farmer is strongest in the middle period, after the firms are well established but before the local industrial community matures.

Women, 80% of whom were hired after 1943, were distributed by their last previous job as follows:

None	49%
Other manufacturing	15
Clerk, telephone, or desk job	13
Service industries	13
Miscellaneous	10

The educational level of newly hired workers has risen during the period studied, although years of education receded slightly during the

war:

Average Education of Men Hired

Dates	*1922-36*	*1937-40*	*1941-43*	*1944-46*	*1947-55*
Years	7.6	7.9	7.2	7.3	9.7

Average Education of Women Hired

Dates	*1922-42*	*1943-45*	*1946-55*
Years	9.4	9.4	9.6

After years of lagging behind, the men caught up with, if not surpassed, the women in educational level. Figure 6 shows the percentage of newly hired males having finished each even numbered grade for the early periods, the war, and recent periods. Since 1941, employees not coming from farms have been significantly better educated than those with farm backgrounds. The percentage of each that had schooling beyond the eighth grade is as follows:

	1941-43	*1944-46*	*1947-55*
Farm background	22%	16%	54%
Nonfarm background	32	56	85

The percentage of newly hired workers having relatives already working for the company provides an index of maturation showing an upward trend at the outset, a reversal during the war, but a renewal of the upward movement after 1950. At all times this percentage was higher for women than for men. See Figure 7.

A major argument for bringing industry into a rural area is that low-income farm workers, who are unwilling to move to find industrial employment, will take local industrial employment that does not require a change of residence. Hence, it is important to know what percentage of the workers hired have *already* worked outside the locality. (A sixty-

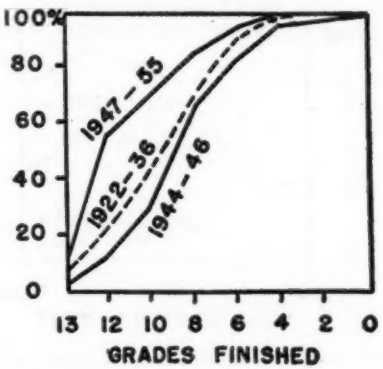

FIG. 6. PERCENTAGE FINISHING GRADES IN SCHOOL

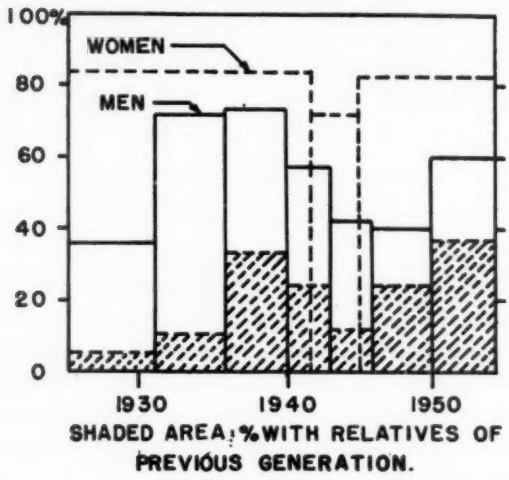

FIG. 7. PERCENTAGE HAVING RELATIVES WITH COMPANY WHEN HIRED

mile radius on the map was chosen as the "locality" since the residence-when-hired figures show that anyone working beyond that distance must almost surely have moved to do so.) In this study, 39% had done so in the early years (23 percent had outside origins), indicating that the new plants were bringing back workers who had once left the area. Thus, around 15% of those hired were such returning sons. From 1937 to 1946 about the same percentage (15%) had worked outside the region as had outside origins. After 1947 this percentage rose to 35% (outside origin 12%) again showing that workers who had once left the area were returning to these local plants.

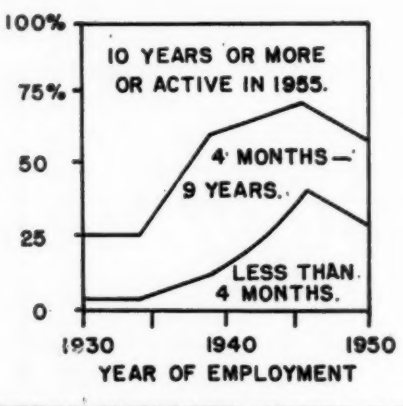

FIG. 8. DISTRIBUTION OF EMPLOYEES ACCORDING TO TIME SERVED BY DATE OF EMPLOYMENT

II. *Comparative Quality of Workers*

To find out who made the better workers—men with farm or nonfarm backgrounds—we used three indexes: (1) the length of time a worker served, (2) whether or not he ever attained a semiskilled position, and (3) in the case of farmer employees, whether or not his separation left him in good standing with the company for re-employment. The chance of promotion and the average time served, as well as the proportion of those hired who had farming backgrounds, showed changes through the years.[3] Only workers hired in the same period could be compared, therefore, it spurious results were to be avoided.

In only two cases was a significant difference observed between farm and nonfarm workers. (1) Of those hired between 1943 and 1946, 25% of the nonfarmers but only 13% of the farmers were promoted. (2) In the period up to 1937, there was a low but significant correlation (0.21) between those with farm backgrounds and those who stayed with the company ten years or more. About 79% of the farmers and 64% of the nonfarmers were in the long-service group. At no time was there a significant difference in standing between farmers and nonfarmers when they left the company. For the period as a whole, 81% left in good standing, the percentage being insignificantly higher for those of farm origin.

A man's last previous job had a much greater influence on his progress with the company than did his farming or nonfarming background.[4] About 30% of those coming from farming as well as those coming from other manufacturing received promotions. About 50% of the group coming from the skilled trades, such as mechanics and electricians, and 50% of those formerly employed as truck drivers were promoted. In the sample, workers from white-collar jobs, painting and carpentering, and those with no previous experience, fell between the farmers and the mechanics in attaining promotion. These groups differed only nonsignificantly (in a statistical sense) from either the farmers and the mechanics. Those from construction labor and service jobs fell below the farmers, but again the difference may be due to chance in the drawing of the sample. Only 7% of the women attained a semiskilled position.

Such findings seem to indicate that, when a firm is considering the establishment of a plant in a particular area, it need not be concerned whether the workers in that locality have been reared on the farm or in town; or whether they have industrial experience, only farm experience, or none. Usually, however, it is still important that there be a few skilled

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[3] *Year hired* | *1922-36* | *1937-40* | *1941-43* | *1944-46* | *1947-55*
Percentage promoted | 73% | 40% | 33% | 16% | 14%
See Figure 8 for changes in the time served.

[4] Employment was not counted a "job" unless held at least four months.

artisans available to move quickly into the semiskilled and skilled jobs. After 25 or 30 years, however, only a small part of these jobs—13% in this study—will be filled by workers already trained.

III. *Conclusions*

The two Kingsport plants drew a little more than half of their workers from farm backgrounds, the exact proportion being highest during the war years and lowest after 1950. Of all employees, 85% originated within a seventy-five mile radius, the geographical concentration diminishing with the increase in distance. The residences of the workers when hired, much more localized than the origins, showed marked changes over time in geographical concentration. These changes, along with trends in the percentage of newly hired workers who were raised on the farm, and in the percentages of those who showed farming, industrial work, and no previous experience as their last job before hiring, indicate that the industries drew most heavily on the farm population after they were well established but were still growing rapidly. However, many of the people hired during the years most favorable to creating off-farm employment for farmers of the area quit soon after hiring, and it is generally felt in the personnel departments that these were rather poor workers. Indeed, all the observed changes during the 1941-46 period may have been due to nation-wide wartime conditions rather than to developments peculiar to the Kingsport area. The decreased concentration of residences when hired in the 1937-40 period, however, suggests that the war merely accentuated rather than created the pattern of changes in this and other indexes.

Our study indicates rather clearly that men reared on the farm and men reared in the town make about equally good workers. Men with previous training in skilled trades or truck driving were more likely to be promoted to the semiskilled level than were the men coming directly from the farms. Just general manufacturing experience alone, however, did *not* appear to give a man any advantage over one fresh from the farm.

ECONOMICS OF RESTORING THE PRODUCTIVE CAPACITY OF A RUN-DOWN DAIRY FARM

R. H. Blosser
Ohio Agricultural Experiment Station

MANY studies show that highly productive farms yield greater profits than ones with badly depleted resources. But few studies show whether or not soil improvement programs can be financed out of current farm earnings.

Soil improvement programs may increase net income after they have been in operation for a period of time. But during the period of establishment expenses may be greater than receipts, especially if labor and capital are paid the customary rates. For example, costs of liming cropland are not recovered on many farms until a meadow crop can be produced and marketed through livestock. Several years usually are required before benefits of permanent pasture improvement are fully realized. Alfalfa meadows cannot be expected to increase corn yields until sufficient time has elapsed to raise them and then plow the residues under. Even after a crop of corn is raised additional time may be needed to convert it to animal products.

The purpose of this paper is to summarize a study designed to determine the profitability of building up the productive capacity of a run-down farm. In this study detailed consideration was given to the following items: (1) annual receipts, expenses and net income for the period of time needed to maximize farm earnings, (2) fixed and operating capital needed to make the necessary improvements, and (3) level of management required to make the soil building program profitable.

Briefly, this study showed a high level of management would be needed if farm earnings were to finance the operations required to restore the productive capacity of a run-down farm in southeastern Ohio. With low producing cows and manufactured milk prices, farm earnings from a soil building program would pay labor and capital only slightly more than average rates after the twelfth year had been reached. Therefore, only a small annual reserve could accumulate to pay previous costs unless these factors received less than customary rates.

With high producing cows and grade A milk prices, soil building operations could be financed out of farm earnings in a few years. If labor and capital were allowed no more than customary rates, current receipts would exceed current expenses after the first three years. If all capital were owned and no interest charge were made for using it, farm earnings would be sufficient to pay more than the average farm wage rate after the first year.

Description of Farm in Run-Down State

This farm consisted of 120 acres of hill land on which soil depleting practices had been followed for many years. No mechanical measures such as terracing or contour strip cropping had ever been established. Soil maps showed that sheet erosion had removed over one-half of the original top-soil from the rotated land. A few shallow gullies also existed where water concentrated as it ran down the slopes. Fertilizer applications on rotated crops averaged only about one-half the prevailing rates used on neighboring farms. Practically no lime had ever been applied to the cropland. Since soils were to acid to grow legumes, timothy was the principal meadow crop.

Approximate yields per acre were as follows: corn 35 bushels, wheat 18 bushels and hay 1.0 tons. Permanent pasture yields also were low because no lime or fertilizer had ever been applied to this crop. Although soil productivity had been badly depleted, buildings for livestock were still in fair condition. Also, the farm house could still be used without making major repairs. Fences were average to poor. But no major clearing of brush was needed on either the cropland or permanent pasture areas.

Profits from this system of farming were low. For example, with slightly below average cows for Ohio but average manufactured milk prices, labor would receive only about $.50 an hour if no interest were charged on capital invested. But if an interest charge of 4 percent were made, this figure would be reduced to about $.20 an hour.[1]

How Soil Building Program Was Evaluated

Net income calculations were made by the synthetic method commonly called farm budgets. By using this procedure all factors could be held constant except the ones under consideration at a particular time. Income data from actual farms would not have given satisfactory results because many other factors could have varied along with the establishment of the soil improvement program.

Receipts, expenses and net income were calculated for a 13-year period which was long enough to cover three complete crop rotations. Observations indicated that this length of time should be sufficient to obtain most of the benefits from the soil improvement program.

Input-output data used in calculating net income were supplied by three studies made on hilly farms located in the eastern part of Ohio. They included the following:

(1) A study of 75 farms on which data were collected on land use,

[1] Based on 1950-54 prices. Calculated receipts were $3,185. Expenses were $2,150 when no interest was charged against capital, and $2,780 when a 4-percent rate was assumed to be paid. Labor requirements were estimated to be 2,025 hours.

fertility practices, crop yields and livestock numbers for 1952. About two-thirds of these farmers were following most of the soil conserving recommendations made by the local soil conservation district. The remainder could be rated poor from the standpoint of soil conservation.

(2) A study of crop production, livestock numbers and farm income on six farms for the period 1937-49. All of these farmers had improved their farms according to the recommendations of the local soil conservation district.

(3) A study of crop production, fertility practices and livestock numbers on 52 farms in 1946. These farms varied considerably in the amount of soil conserving practices used.

Soils considered were Muskingum and associated types, which are roughly representative of about 15 million acres of land in Southern Indiana, Southeastern Ohio, Northern Kentucky and Northern West Virginia. These soils erode easily because of steep slopes that range from 10 to 30 percent. Soils maps often show losses amounting to more than half of the original topsoil. Muskingum and associated soils are unglaciated and have developed from sandstone and shale. They are acid in reaction except where liberal amounts of lime have been applied recently.

Calculations were limited to a 120-acre farm operated by the owner. Census data showed that this is a typical size farm for Southeastern Ohio. Crop production was calculated from the following acreages: corn 12, wheat 14, meadow 34, permanent pasture 36, woods and miscellaneous 24. These acreages were determined from land capability classes used locally to develop cropping programs to control erosion and improve soil productivity. Meadow acreage was slightly higher than corn and wheat combined, although a 4-year rotation of corn, wheat and 2 years of meadow was used. Correction areas produced by contour strip cropping accounted for this difference. Contour strip cropping was considered necessary to maximize grain acreage and reduce soil losses to the minimum.

Total crop production on the rotated land was calculated from the yields in Table 1. These yields were based on the use of contour strip cropping and heavy applications of fertilizer and lime. Therefore, they are considerably higher than the yields obtained under the system of farming that depleted soil productivity.

Rotation pasture yields were based on the type and amount of hay assumed to be raised. The carrying capacity of permanent pastures was determined from experimental data based on using heavy applications of lime and fertilizer.

Dairy cows were selected to utilize the hay and pasture because this

TABLE 1. CROP YIELDS USED IN CALCULATING PRODUCTION FOR THE SOIL REBUILDING PROGRAM

Crop	Rotation			
	First	Second	Third	Fourth
Corn, bu.	50	58	62	65
Wheat, bu.	22	24	25	26
Hay, tons	1.0[1]	2.0[2]	2.5[3]	2.8[3]

[1] Timothy only.
[2] Red clover and timothy with some alfalfa.
[3] Alfalfa, clover and timothy.

type of livestock prevails on many southeastern Ohio farms. Beef cattle and sheep were not considered because they would require more than 120 acres to use all of the labor of a full-time farmer. A small flock of poultry might have been considered in the livestock program. But this enterprise was omitted to simplify calculations. One or two hundred hens would not have changed conclusions significantly. Poultry would only have substituted for some of the hogs because both are principally grain consuming animals.

Calculations in Table 2 show the amount of livestock that could be kept on the feed assumed to be produced. Average Ohio livestock feeding standards were used in figuring feed requirements for each animal. The number of dairy cows and replacements was determined from the amount of hay and pasture the farm would produce. The number of hogs was based on the amount of corn left after deducting the requirements for the dairy herd.

Dairy cows were calculated to double during the 13-year period. The number of hogs did not change significantly when 5,800 pound cows

TABLE 2. CALCULATED LIVESTOCK NUMBERS FOR A 120-ACRE FARM

Year	Dairy Cows	Mature Dairy Replacements	Market Hogs with	
			5,800 lb. Cows	9,000 lb. Cows
1st	10	0	27	23
2nd	10	0	26	21
3rd	10	4	26	20
4th	11	4	25	18
5th	12	4	30	23
6th	13	4	29	21
7th	14	4	28	18
8th	15	4	27	15
9th	16	5	29	16
10th	17	5	28	14
11th	18	5	27	12
12th	19	5	26	11
13th	20	4	28	11

were used. But with 9,000 pound cows, hog numbers for the thirteenth year were only about one-half the amount for the first year. Forage consumption per cow was assumed to be the same regardless of milk production. But the high producing cows were allowed about one-half more grain than the low producing ones. Therefore, less grain was available for hogs when high producing cows were used instead of low producing ones. Also, as more 9,000-pound cows were assumed to be kept, less corn was available for hogs.

Calculated Income for Low Producing Cows and Manufactured Milk Prices

Calculations were made first for cows producing 5,800 pounds of 4-percent milk selling at $3.45 per hundredweight. This situation is typical of the poorer dairy farms in southeastern Ohio. Average production per cow in Ohio is now about 6,800 pounds. But the United States as a whole averages only about 5,800 pounds. Capital invested in this type of farming was estimated to be $16,200 for the first year and $19,560 for the thirteenth year. Higher land values and more livestock in the thirteenth year were responsible for this increase.

Capital investment needed for this system of farming was estimated as follows: The value of land was increased each year by an amount equal to the cost of lime used in excess of maintenance applications. This procedure increased the inventory value of land and fences from $3,000 to $5,000 during the 13-year period. Buildings were depreciated at the rate of $120 per year. This reduced their value from $6,000 to $4,560. Livestock was increased in value from $2,200 to $5,000 because of the increase in numbers during the 13-year period.

Machinery investment was kept down to $5,000 by assuming that some second hand equipment would be used. Also, custom owned machinery would be hired to harvest the corn and wheat. But a hay baler was considered necessary to harvest the meadows at the proper time. Annual investment in machinery was kept the same by assuming that some new pieces would be bought occasionally. In estimating capital needs average values were used for the 5-year period 1950-54.

Gross receipts were calculated to increase from $3,070 to $6,384 during the 13-year period. This doubling of receipts came principally from raising the sale of milk and old cows from $1,946 to $4,647. Annual sales of hogs and wheat did not change significantly. Hogs increased gross receipts about $1,100 each year while wheat added about $500.

Prices used in calculating gross income were averages received by Ohio farmers for the 5-year period 1950-54. Averages for this period were used to minimize effects of short-time changes in price relationships. The

price of milk used was $3.45 per hundred pounds after deducting hauling charges. This was the average price paid to farmers for manufactured milk. The price used for hogs was $20.82 per hundred pounds. Wheat sales were figured at $2.04 per bushel.

Estimated annual expenses for the entire farm fluctuated around $3,000 throughout the 13-year period. Although the number of cows was calculated to double, hay and pasture improved enough to keep the annual feed bill at approximately $600. Machinery costs were increased about $200 because of harvesting more hay for the additional livestock. Annual costs of lime for the first 3 years averaged about $750 compared with $200 for each of the next 10 years. Smaller applications would have reduced immediate costs. But less lime in the early years of the soil improvement program would also have delayed the time when maximum benefits could be realized. Fertilizer costs were estimated to be about $450 for each year. Annual expenditures for seed amounted to $200. Other expenses such as building repairs and taxes were about the same for each year.

Net income calculations in Table 3 show that labor could not be paid anything out of farm earnings the first year, even if no interest charge were made on the capital invested. Cash expenses alone for the first year would amount to $226 more than gross receipts. If a 4-percent inter-

TABLE 3. CALCULATED INCOME AND LABOR REQUIREMENTS FOR LOW PRODUCING COWS AND AVERAGE MANUFACTURED MILK PRICES

Year	Labor Income With		Return Per Hour of Labor With		Hours of Labor Needed
	No Interest Charge	4% Interest Charge	No Interest Charge	4% Interest Charge	
1st	−$ 226	−$ 874	−$.12	−$.46	1,908
2nd	421	− 270	.20	− .13	2,100
3rd	299	− 419	.13	− .19	2,244
4th	1,371	633	.58	.27	2,346
5th	1,692	947	.68	.38	2,485
6th	1,362	1,110	.72	.43	2,604
7th	2,000	1,241	.73	.45	2,735
8th	2,281	1.515	.80	.53	2,867
9th	2,485	1,711	.82	.57	3,018
10th	2,807	2,026	.90	.65	3,121
11th	2,967	2,188	.93	.68	3,204
12th	3,098	2,311	.95	.71[1]	3,278
13th	3,335	2,553	.99	.76	3,356
Average	1,876	1,128	.69	.42	2,718

[1] A financial statement for the first 11 years (until labor and capital could be paid average rates or more) showed the following: Total cash receipts, $50,966; Expenses, including a payment of $.70 an hour for labor and 4 percent on capital, $61,206; Increase in capital invested, $3,400; Loss, $6,840.

est charge were made against capital, farm earnings would not be sufficient to pay labor anything before the fourth year.

For the 13-year period as a whole returns to all labor would average only about $.69 an hour if no interest were charged on capital. But if 4-percent interest were charged, this figure would be reduced to $.42.

These computations show some of the difficulties of financing the early stages of the soil rebuilding program from the earnings of the farm. During 1950-54 Ohio farm wages averaged about $.70 an hour plus the use of a house. But the soil building program would not return this much to labor before the sixth year, even if no interest were charged on capital invested. If a 4-percent interest charge were made, the average farm wage rate could not be paid out of farm earnings until the twelfth year.

Even after net income was maximized labor and capital could be paid only slightly more than average rates. Consequently financial reserves would accumulate so slowly that about 45 years would be needed to repay all previous costs. This amount of time would be needed even if credit were given to the build-up in inventory which could not be taken out of the farm business to pay cash expenses.

Capital investment was estimated to increase $3,360 during the 13-year period. Since this amount represented additional investments in lime and livestock it could not be used in any way to pay cash expenses. If it had been credited to labor earnings for the 13-year period, it would have increased them only about $.10 an hour for all labor used.

If any capital were borrowed additional income would be needed to make repayment on principal. Since most lending agencies require some repayment on loans each year, it is difficult to imagine how any sizeable amount could be borrowed on the farming operations just described. If $2,500 were used annually for family living expenses no payment of interest or principal could be made out of farm earnings before the tenth year.

How then could such a program be financed with low producing cows and manufactured milk prices? It might be done by using capital on which no interest had to be paid. Also, some off-farm income might be used to support the family during the first several years of the rebuilding program. At that time, labor requirements would be about 1,000 hours less than needed in the thirteenth year. A slow rate of adopting a soil improvement program might be used to keep annual expenses down. But it also would delay the time when the program would yield the maximum income.

Net income was not calculated for the poorest farm situations. New buildings, land clearing, or lower milk prices would have made the soil building program still more difficult to finance than preceding figures indicate.

Calculated Income for High Producing Cows and Grade A Milk Prices

This combination was found only on a small percentage of farms. It included cows averaging 9,000 pounds of 4-percent milk selling at $4.45 per hundred pounds after deducting hauling charges. Capital invested in this type of farming was estimated to be $18,700 for the first year and $23,000 for the thirteenth. Land and machinery were valued the same as when low producing cows and manufactured milk prices were used. But buildings were increased about $1,500 to produce Grade A milk and the better cows were inventoried about one-half higher.

Calculated gross receipts were $4,892 for the first year and $9,755 for the thirteenth. This difference came principally from increasing the dairy receipts from $3,934 to $8,639. Receipts from hogs declined from $958 to $458. Receipts from wheat increased from $521 the second year to $658 for the thirteenth. Annual farm expenses fluctuated around $3,200.

Net income calculations in Table 4 show that farm earnings would be sufficient to pay the average farm wage rate after the first year, if no interest were charged against capital. If a 4-percent interest charge were made the customary wage rate could be paid after the third year. Increase in capital invested also would credit labor with about $.13 an hour for the 13 year period.

TABLE 4. CALCULATED INCOME AND LABOR REQUIREMENTS FOR HIGH PRODUCING COWS AND GRADE A MILK PRICES

Year	Labor Income With		Return Per Hour of Labor With		Hours of Labor Needed
	No Interest Charge	4% Interest Charge	No Interest Charge	4% Interest Charge	
1st	$1,271	$ 523	$ .64	$ .26	1,984
2nd	1,885	1,087	.87	.50	2,170
3rd	1,763	931	.76	.40	2,308
4th	3,023	2,169	1.25	.90[1]	2,414
5th	3,529	2,665	1.38	1.04	2,563
6th	3,848	2,974	1.43	1.11	2,686
7th	4,154	3,270	1.48	1.16	2,815
8th	4,610	3,716	1.57	1.26	2,945
9th	4,971	4,067	1.60	1.31	3,100
10th	5,456	4,542	1.70	1.42	3,207
11th	5,778	4,858	1.75	1.47	3,294
12th	6,100	5,174	1.81	1.53	3,378
13th	6,467	5,547	1.87	1.61	3,454
Average	4,066	3,194	1.46	1.14	2,794

[1] A financial statement for the first 3 years (until labor and capital could be paid average rates or more) showed the following: Total cash receipts, $15,514; Expenses, including a payment of $.70 an hour for labor and 4 percent on capital, $17,497; Increase in capital invested $2100; Gain $117.

These figures show that after the first three years current receipts will exceed current expenses if labor and capital were allowed no more than the customary rates. Also, if capital accumulation is credited to farm earnings, all costs of the soil improvement program can be recovered by the end of the third year. If $2,500 were used annually for family living, interest and principal payments on borrowed money could be made out of farm earnings after the third year.

Although a soil building program may be profitable, returns from a given amount of labor and capital applied to a highly productive farm could often be more profitable. Also a job in town might still be the best alternative, especially for an average farmer who did not possess the necessary capital needed for farming.

POSTWAR FAMILY EXPENDITURE STUDIES IN WESTERN EUROPE

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MANY of the countries of western Europe, like those in North America, have undertaken national studies of family incomes and expenditures since the end of World War II, primarily for the purpose of revising outmoded cost-of-living index bases. The International Labour Office and the United Nations Organization also have shown increased interest in family living studies in the last decade.[1] These organizations give technical assistance and advice to agencies undertaking family expenditure studies in an effort to encourage better sampling methods and more uniform classification of results.

In contrast to North American practice, most European countries favor the account book method of obtaining family expenditure data over the interview method. Nine of the thirteen countries of western Europe which have carried out or are carrying out national family expenditure studies since the end of World War II have used the account book method. Also in contrast to North American practice, most European governments renumerate the participating families to some extent; payments varied from approximately $4 in Austria to $6.25 in the Netherlands and approximately $60 per family in Belgium.

This article summarizes the sampling methods, coverage and results of the major postwar *national* family expenditure studies of western Europe and studies planned for the immediate future.[2]

1. *Netherlands:* The Netherlands government carried out a family income and expenditure study covering 3,000 families of all income groups in 1951 in order to revise the cost-of-living index base.[3] The study, undertaken by the Central Bureau of Statistics (Centraal Bureau Voor De Statistiek), was designed to cover all income and occupational groups except farmers; agricultural workers, manual workers, civil servants and relief persons are examples of the occupations included. The account

* The author would like to express her appreciation to all personnel of the west European governments who commented on an earlier draft of this article.

[1] International Labour Office, *Methods of Family Living Studies* (Geneva, 1949), and United Nations, *Report on International Definition and Measurement of Standards and Levels of Living* (New York: 1954).

[2] When cost-of-living index revisions were based on area rather than national studies, the area studies have been included. However, no attempt has been made to summarize all area studies carried out since the war.

[3] Centraal Bureau Voor De Statistiek, *Nationaal budgetonderzoek 1951* (Utrecht: Uitgeversmaatschappij W. De Haan N. V., 1954). Series A, No. 1 is on methodology and one section of series B is for each occupational group. For example, series B3, No. 2 is "Household Expenditures of Higher Employees and Higher Civil Servants, According to Residence, Size of Family and Income."

book method of data collection was used. Each family selected was asked to keep records for one year in return for 25 guilders (about $6.25). Records were audited each week; quantities of goods purchased were recorded as well as expenditures. Home-produced articles and foods were valued at the prevailing retail prices in the district. If the home-produced article (for example, a dress) cost only one-half of the retail value, the difference between the retail value and the cost was added to both income and expenditure. Approximately 20 percent of the original starting families did not complete records for the entire year.

Results of this study indicated that income, size of family and location rather than occupation were the important determinants of expenditure patterns. Consequently follow-up studies which were carried out in 1952, 1953, and 1954 covered only skilled manual and middle income employees and civil servants.[4] These studies were carried out primarily to determine if the percentage of income allocated to the major expenditure categories had changed since 1951.

During the period April 1955 to March 1956 another survey was carried out among four-person families of wage earners, salaried employees and agricultural workers with incomes from 3,000 to 5,000 guilders. In addition, in October 1955 a pilot study among farmers' families (the only social group which was not included in the Budget enquiry of 1951) was carried out in preparation for a more extensive enquiry among farmers which is under consideration. In this pilot study the interview method was used for the first time for part of the families included.

2. *Belgium:* The Belgian government has not undertaken directly a study of family expenditures since 1929. As a result the cost-of-living index has not been revised in the postwar period despite repeated requests to Parliament for the necessary funds. However, the government has contributed financial assistance to a group at the University of Brussels (Institut Universitaire d'Information Sociale et Économique) to undertake two studies since the war. One of these studies was carried out in 1947-48,[5] when prices and wages were still controlled and rationing existed, and the other[6] a year later when these controls were no

[4] Centraal Bureau De Statistiek, *Huishoudrekeningen 1952,* Uitgaven- en verbruiksrekeningen van gezinnen van geschoolde handarbeiders en gezinnen van middelbare employé's en ambtenaren (Utrecht: Uitgeversmaatschappij W. De Haan N. V., 1954).

[5] G. Jacquemyns, *Les Budgets Familiaux d'Ouvriers et d'Employés 1947-1948,* Institut Universitaire d'Information Sociale et Économique (Brussels: Parc Léopold, 1949).

[6] G. Jacquemyns, *Mode de Vie des Ouvriers 1948-1949,* Institut Universitaire d'Information Sociale et Économique (Brussels: Parc Léopold, 1951). The French term *ouvrier* is used for skilled and unskilled manual workers while the term *employé* covers clerical workers including department store clerks, stenographers, civil servants, and so forth.

longer in effect. The 1947-48 study covered 370 families of workers and employees and the 1948-49 study covered 387 families. The samples of both studies were considered inadequate by personnel in the Ministry of Economic Affairs who administer the retail price index. However, the latter study is an improvement over the former in this respect. In both cases families were chosen from lists of members of trade unions and other organizations. The account book method was used; each participating family was paid the equivalent of $60 a year to cooperate.

3. *Luxembourg:* The government of Luxembourg has never made a national study of family expenditures. The cost-of-living index revision of 1948 was completed without a budget enquiry as a guide. However, the Commission responsible for the revision made some use of the University of Brussels study of Belgian family expenditures.

Although the Luxembourg government has not conducted a study of family expenditures, one of the most interesting studies ever attempted of a comparison of the expenditure patterns, incomes and prices in six countries, undertaken simultaneously with common schedules and sampling methods, is now being carried out in that country. This is a study undertaken by the European Coal and Steel Community, High Authority, whose head offices are in Luxembourg City. The study is intended to cover families employed in coal mines and steel mills in the member countries of Belgium, Luxembourg, Netherlands, West Germany, France and Italy. The family budget section will be conducted in 1956. Summaries of the income and price studies have already been published.[7] The methodology and results of the complete study will be followed with keen interest by students of consumption economics.

4. *France:* The French National Institute of Statistics and Economic Studies (L'Institut National de la Statistique et des Études Économiques) has carried out a large number of area studies since 1946, most of which have been urban. Only the studies used for revision of the cost-of-living index and the most recent large area study will be cited here.

The cost-of-living index was revised in 1949 after expenditure patterns of 831 families in the Paris area, interviewed between April and June of 1948,[8] and 758 wage-earning families, also in the Paris region, interviewed during the autumn of 1948[9] were examined. Random sam-

[7] Communauté Européenne du Charbon et de L'Acier, Haute Autorité, "Taux d'équivalence de pouvoir d'achat à la consommation dans les pays de la Communauté," *Informations Statistiques,* 2è année No. 5, Août-Septembre 1955 and "Comparaison des prix des biens de consommation et des services," *Informations Statistiques,* 2è année, No. 1, Janvier 1955.

[8] Institut National de la Statistique et des Études Économiques, *Bulletin de la Statistique Générale de la France,* Supplément Janvier-Mars 1949 (Paris: Presses Universitaires de France, 1949).

[9] *Ibid, Bulletin de la Statistique Générale de la France,* Supplément Oct.-Dec.

pling of households was employed but only families of husband and wife without children or with one, two or three children under 16 years of age were included. Refusal rates were as high as 40 percent even though income information was not asked.[10] Detailed food expenditure data were kept for one week as were expenditures on miscellaneous items; other expenditures were estimated for the whole year.

As has been already noted, these 1948 studies were confined to wage-earning families in the Paris area. Subsequently, in November and December of 1951, over 2,500 households of all social conditions were interviewed in Paris, Rennes, and the 17 large cities of Provence.[11] This study attempted to ascertain incomes as well as expenditures but the attempt was unsuccessful as far as income data were concerned. In 1952 a study of expenditure patterns of 652 farm-owning families was carried out.[12] The National Institute of Statistics and Economic Studies (known as I.N.S.E.E.) hopes to continue to obtain more adequate coverage of rural family expenditures in the future. Starting in the month of April 1956, the French I.N.S.E.E. has begun a survey of 6,000 families selected to represent the entire country.

5. *West Germany:* The Statistical Office (Statistisches Bundesamt) of the West German government also has carried out a number of area studies since the end of World War II. The consumer price index was revised in 1952[13] (on a 1950 base); the revision was based on studies of family expenditures carried out from 1949 to 1952. West Germany has three consumer price indexes—for the low, middle, and upper income groups, respectively. The family type for all three indexes is four persons with at least one breadwinner. The low-income group has a maximum income of DM 210, the middle income group of DM 360, and the upper income group a maximum income of DM 650. Studies used for the revision of the consumer price indexes were based on expenditures of urban families living in cities of 20,000 or over population.

The Statistical Office also has about 250 middle income working class

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1949, "Les Dépenses et les Consommations des Familles de Salariés de la Région Parisienne Pendant L'Autonme 1949," (Paris: Presses Universitaires de France, 1949).

[10] The autumn study confirmed the results of the spring study that refusals were higher among families without children than among families with children; that workers refused more often than employees; and that the level of living appeared to bear no relation to the refusal to cooperate.

[11] I.N.S.E.E., "Les Dépenses et les Consommations des Ménages à Paris, Rennes et des 17 Grandes Villes de Province Novembre-Décembre 1951," *Bulletin Mensuel de Statistique,* Supplément Octobre-Décembre 1953.

[12] *Ibid, Bulletin Mensuel de Statistique,* Supplément Juillet-September 1954, "Une Enquête sur les Dépenses des Ménages d'Exploitants Agricoles en 1952."

[13] *Wirtschaft und Statistik,* "Der Neue Preisindex für die Lebenshaltung," Nov. 1952 (Wiesbaden: Statistisches Bundesamt).

urban families most of whom have kept family expenditure records continuously since 1949.[14] Account book methods of data collection are used; families are paid approximately $15 a year to cooperate. In 1953 a study of the expenditure patterns of families of farm owners and farm laborers was made. Results of this study were planned to be released in 1955.

6. *Switzerland:* The Swiss government has carried out national urban studies of family incomes and expenditures in 1921, 1936-38 and annually since 1943. The cost-of-living index was revised in April 1950 on the basis of a study carried out in 1948 by the Swiss Fédéral Office of Industry, Handicrafts, and Labor[15] (De l'Office fédéral de l'industrie, des arts et métiers et du travail). Families were asked to cooperate through the local and labor newspapers. Each family received about $18 for cooperating. Only urban families with children were included. The 1948 study covered 267 families, of which 191 were wage-earners and 76 were salaried. Detailed quantity data on food consumption were ascertained as well as income and expenditure data. The account book method of collection was employed. The Swiss Federal Office releases the data in such a manner that changes from one year to the next are readily comparable.

In addition to the national family budget studies, the cities of Zurich and Basle have carried out family budget studies for some years.[16] Results of the city studies are then forwarded to the Federal Office.

7. *Austria:* In the inter-war period the Vienna Chamber of Labor regularly carried out expenditure studies covering one year periods for a small number of workers' families. Adjusted results of these studies which had been carried out in the thirties formed the basis of the post-war cost-of-living index of the Austrian Institute for Economic Research (Österreichisches Institut für Wirtschaftsforschung), a private research agency. The Austrian Central Statistical Office, a government agency, has not published a cost-of-living index to date.

After World War II three or four local Chambers of Labor in Vienna and in the Austrian provinces (Bundeslaender) were carrying out workers family expenditure studies as they had before the war. But these studies

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[14] "Der Verbrauch in Arbeitnehmerhaushaltungen in Jahr 1954," *Wirtschaft und Statistik*, Mai 1955 (Wiesbaden: Statistisches Bundesamt).

[15] *Le Vie Economique*, "Budgets Familiaux de la Population Salariée, Années 1943 à 1952," No. 11, Novembre 1953.

[16] "Wirtschaft und Verwaltung," *Vierteljahrshefte herausgegeben von Statistischen Amt des Kantons Basel-Stadt*, Okt.-Dez. 1950, and Statistisches Amt der Stadt Zürich, *Zürcher Statistische Nachrichten*, 1954 Heft 1. Of the 133 families who cooperated in the city of Zurich study in 1954, only 3 families owned automobiles although incomes of 13,000 Swiss francs and upward (about $3,250) were recorded. It was pointed out that a high percentage of the many autos seen in Switzerland are company and business cars.

were limited in scope, coverage and selection procedure, and their results were not published at all or not in detail. Hence the National Income Research Unit (Forschungsstelle zur Aufstellung volkswirtschaftlicher Bilanzen), a working party of the Austrian Central Statistical Office and the Austrian Institute for Economic Research decided in 1954 to carry out a nationwide consumers survey in order to obtain an improved basis for weighting the consumer price index and to obtain aggregate consumption figures for national accounting purposes.

The survey covered the whole urban population. A random sample of 9,570 households was chosen. Each month one-twelfth of the 9,570 households was selected and each household was asked to record its expenditures for one month. Income and changes in assets were not requested. Each household was furnished with an account book and was paid 100 Austrian Schillings (approximately $4) to cooperate. This amount was assumed to be large enough to convince the housewives of the importance of the enquiry but not to be large enough to cause a selection bias.

At the end of the year 7,019 monthly records of as many households had been obtained. The response rate was 74 percent; 16 percent of the total sample refused to cooperate and 10 percent could not cooperate because of death, demolition of buildings, etc. The response rate varied from 93 percent of the salary earners outside Vienna to 52 percent of the entrepreneurs in Vienna. Results of the study were released in 1956 showing classifications by area, by economic status of the head of the household, by size of the household, by total expenditure level of the household and by expenditure categories.[17]

8. *Italy:* Family budget studies were carried out in Italy as early as 1878. However, when the Italian cost-of-living index was revised in 1951-52 it was based on a theoretical family of four with no recent national family expenditure study as a guide.[18] Since that time two important studies have been carried out by the Central Institute of Statistics (Instituto Centrale di Statistica). The first was in 1952 when a special study covering 1,322 unemployed families and 1,847 poor families was undertaken.[19] The second is a national survey of about 25,000

[17] "Der Verbrauch der staedtischen Bevoelkerung Oesterreichs. Ergebnisse der Konsumerhebung 1954-55." Edited by Forschungsstelle zur Aufstellung volkswirtschaftlicher Bilanzen (Wien: 1956).

[18] *Quaderni della Rassegna Statistiche del Lavoro,* "Le Nuove Norme per la Rile Vasione Degli Indici del Costo della Vita ed Il Sistema Di Saala Mobile dei Salari," Quaderno VII, Settembre 1952. Also there have been city family living studies carried out by the Doxa Institute in Milan and the Fiat Company.

[19] Results of these studies were published in "Proceedings of the Parliamentary Enquiry Commission for Unemployment" and "Proceedings of the Parliamentary Commission on Poverty."

urban families throughout Italy which is going on at the present time. Families have been asked to volunteer to keep accounts for one, three, or twelve-month periods. These families will be given no remuneration; however, the importance of the study is widely recognized as a result of agreements passed between management and labor unions in 1947, 1951 and 1952 which tie wages in industry, commerce and agriculture to the cost-of-living index.

9. *Spain:* Spain has had a cost-of-living index since 1936. No study of family budgets has ever been undertaken by the National Statistical Office (Instituto Nacional de Estadistica). In 1936 and immediately after the revolution the National Statistical Office personnel felt that a family budget study would be considered undue prying into the personal affairs of the nation's families. Now the personnel feel that conditions are suitable for a study and they hope to get one underway during the next year. Present tentative plans call for a survey of both urban and rural families, with the use of the account book method.

10. *Portugal:* Portugal revised its cost-of-living index in 1948. The National Statistical Office (Instituto Nacional de Estatistica) has carried out three postwar urban family expenditure studies in the major cities and is at present carrying out similar studies in two other cities. The first of these studies was in Lisbon in 1948-49,[20] carried out to assist in the revision of the cost-of-living index. The second was in Porto in 1950-51 and the third in Coimbra in 1953-54. In each case 200 families were selected. Household addresses were drawn at random from lists of members of trade unions and professional syndicates. Families included must have at least three persons with husband and wife both living. The account book method is used, with all expenditures except food being entered each day. Food data are obtained from four detailed fourteen-day studies, and for the balance of the year only total food expenditures are reported. Families are paid about $14 if they complete records for the entire year. Information is obtained on incomes as well as on expenditures, with an upper income limit of about $235 a month.

11. *Denmark:* Denmark carried out a family budget study in May and June of 1949,[21] primarily to revise the base of the cost-of-living index. Four hundred and forty-three families were surveyed, the interview method being used for the first time. The population group included wage-earners and salaried employees without regard to income; the family type used was husband and wife with and without children.

About a month ago the Danish Statistical Department started a new

[20] Portugal, Instituto Nacional de Estatística, *Inquérito ao custo de vida na cidade de Lisboa, 1948-1949*, "Estudos" No. 23, 1953.

[21] Danmarks Statistik, "Forbrugsundersøgelsen 1948 og det ney Pristalsbudget," *Statistiske Efterretninger*, 41 Argang Nr. 58, 1. November 1949.

family budget enquiry which is much more comprehensive than the 1948 study. The 1956 study will include 3,500 wage-earner families of all types including single, widowed and divorced persons and 250 old age pensioners. This enquiry will ascertain family expenditures, savings, capital and debts. The interview method will be used principally, with the account book method being used for food. About 200 families will keep food expenditures for a three-week period; at the end of that time 200 additional families will start keeping food records. In this way all seasons of the year will be represented.

12. *Norway:* The Norwegian Central Bureau of Statistics (Statistisk Sentralbyrå) has conducted national expenditure studies in 1947-48 and in 1951-52. The former study covered 452 workers' families in urban areas.[22] The 1951-52 study contained a sample of 100 families selected from among the 452 families of the earlier study in such a way as to represent all family types.[23] The investigation covered families made up of husband and wife with or without children under 15 years of age. Data collected covered accounting of incomes and expenditures for a period of one year, by the account book method. For food and fuel, data were also obtained on quantities consumed. Both studies have been used to revise the base of the cost-of-living index, a major revision of which took place in 1949.

13. *Sweden:* The latest Swedish national family expenditure study was carried out in 1952 by the Social Welfare Board (Socialsytrelsen).[24] The random sample included about 600 households covering the entire country and all social classes. Households were classified on the basis of husband and wife with and without children, single households, and mixed households (families with several members—with adult children at home, with or without younger children). The interview method was used for the collection of the data, together with 14-day account-book records to obtain details of food consumption in each household.

Data were obtained on incomes, savings, and taxes as well as on consumption expenditures. Home-produced goods were valued at retail prices. Purchases and amortization of owner-occupied homes were considered as investments and were not included in the category of consumption expenditures. Refusal rates were as low as 6 percent of the total sample. Nonresponse accounted for another 7 percent.

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[22] Statistisk Sentralbyrå, *Husholdningsregnskaper mai 1947-april 1948.*

[23] *Ibid, Husholdningregnakaper oktober 1951-september 1952,* Norges Offisielle Statistikk XI. 128 (Oslo: I Kommisjon Hos H. Aschehoug & co., 1953).

[24] Social Welfare Board, *Family Expenditures in Sweden, 1952,* (Stockholm: 1955), an English summary of the current study, which is in mimeographed form, and "Några viktigare resultat från socialstyrelsens levnadskostnads-undersökning 1952," *Sociala Meddelanden,* 1954 No. 1 and "Levnadskostnaderna 1952," Sveriges Officiella Statistik, (Stockholm, 1956) to be released soon.

14. *Finland:* The Finnish Ministry of Social Affairs (Sosiaaliminsteriön Sosiallinen Tutkimustoimisto) carried out an investigation of family expenditures from February 1950 to January 1951,[25] primarily to be used as a basis for revising the Finnish cost-of-living index. The account book method was used; food expenditures were obtained in detail during four fortnightly periods while other categories of consumption were recorded for the whole year. The family type selected was that of husband and wife with or without children. Families selected were urban wage and salary earners. The 538 cooperating families were chosen by a local agent working with the local representatives of the trade union district. Income data were obtained, as well as expenditure data.

15. *Ireland (Eire):* The Eire Central Statistical Office carried out a household budget enquiry during 1951-52[26] to provide a basis of weights for the new consumer price index. About 3,100 families selected at random agreed to furnish four weekly returns showing expenditures for the week. (About 60 percent of the households selected agreed to keep records.) Account book methods were used; the survey was confined to urban areas. Income and expenditure data were both obtained.

16. *Great Britain:* Great Britain revised its retail price index in 1952[27] without a new national family budget enquiry, the last one having been carried out in 1937-38. However, a family budget study was instigated between January 1953 and January 1954. About 20,000 households of all types and income groups living in urban and rural areas in the United Kingdom of Great Britain and Northern Ireland were visited during the course of the enquiry, with about 13,000 households cooperating in the study. Results and methodology have not been released to date.

Results of These Studies

The results of these studies of expenditure patterns of European wage-earner families are collected by the International Labour Office and are published annually in the *Yearbook of Labour Statistics*. In an attempt to make the data more comparable from country to country the I.L.O. excludes from total consumption expenditures taxes, interest on personal debts, repayments of debts, and savings. The food expenditures include expenditures for alcoholic beverages and meals consumed away from home. The clothing total also includes laundry service.

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[25] The Finnish government documents are published in Finnish and Swedish. The Swedish reference is, "Levnadskostnadsundersökningen Februari 1950-Januari 1951," *Sociala Specialundersokningar XXXII*, Finlands Officiella Statistik, 1954.

[26] Central Statistics Office, *Household Budget Inquiry 1951-1952*, (Dublin: Stationery Office, 1954).

[27] Ministry of Labour and National Service, *Interim Index of Retail Prices*, Revised edition (London: Her Majesty's Stationery Office, 1952).

TABLE 1. PERCENTAGE DISTRIBUTION OF TOTAL CONSUMPTION EXPENDITURES AMONG THE MAJOR CONSUMPTION CATEGORIES, FAMILIES OF WAGE EARNERS IN THE COUNTRIES OF WESTERN EUROPE AND NORTH AMERICA*

Country	Year	Total Consumption Expenditures	Food	Housing				Clothing	Misc.
				Rent	Fuel & light	Furnishings Upkeep, etc.	Total		
			%	%	%	%	%	%	%
Austria	1954	24,600 A.S.	52.8	4.5	4.7	4.8	14.0	14.5	18.7
Belgium	1948–9	68,881 B.fr.	47.4	5.8	6.3	3.0	15.1	14.4	23.1
Denmark†	1948	8,912 Kr.	33.1	8.8	5.9	5.6	20.3	16.0	30.6
Finland†	1950–1	312,189 mk.	48.2	5.9	3.3	5.0	14.2	18.1	19.5
France	1951	566,800 fr.	60.2	3.4	5.1	2.5	11.0	9.4	19.4
W. Germany†	1953	4,900 DM	47.7	9.1	6.8	4.9	20.8	14.3	17.2
Ireland	1951–2	475£	45.5	6.1	7.6	5.2	18.9	12.7	22.9
Italy			not yet available						
Netherlands	1951	3,757 fl.	36.7	6.7	5.7	7.9	20.3	9.9	33.1
Norway	1951–2	10,356 Kr.	38.8	7.2	2.9	7.8	17.9	16.2	27.1
Portugal-Lisbon†	1948–9	32,364 Es.	52.6	11.1	4.2	—	15.3	10.5	21.6
Porto	1950–1	19,284 Es.	62.6	9.2	5.8	—	15.0	8.1	14.3
Sweden	1952	9,700 Kr.	36.5	13.3		6.2	19.5	13.0	31.0
Switzerland	1952	8,901 Fr.	37.5	13.8	5.2	4.2	23.2	13.4	25.9
U.K.	1953–4		not yet available						
Canada	1953	$3,923	30.1‡	17.3		10.9	28.2	10.5	31.2
U.S.A.	1952	—	32.4	17.2§	3.2	11.6	32.0	9.7	25.8

* Source: *Yearbook of Labour Statistics, 1954*, pp. 295–297 except for Canada, Austria and Sweden. Canada, Dominion Bureau of Statistics, Reference Paper No 64, *City Family Expenditures, 1953*. Austria from Austrian Institute for Economic Research and Sweden from Social Welfare Board.

† Manual and nonmanual workers families. Nonmanual workers are salaried employees and civil servants.

‡ Alcoholic beverages are not included in the food expenditures in Canada.

§ Including home maintenance by owners.

The percentage distribution of total consumption expenditures among the major expenditure categories is shown in Table I. For purposes of comparison, similar data for Canada and the United States are included at the bottom of the Table. However, in these two countries and in Sweden data presented are averages for all occupational groups rather than wage-earner families alone.

Summary

Thirteen of the sixteen countries of western Europe have undertaken or are undertaking national studies of family expenditures since the end of World War II, either by governmental agencies or private research organizations. Data on three of these studies have not yet been released –Austria, Italy and Great Britain. Of the three countries which have not completed national budget studies, Portugal has carried out studies in five of the principal cities, Luxembourg will be included in the study

now underway by the High Authority of the Coal and Steel Community and Spain plans to undertake a study in the near future. The thirteen countries that have completed national budget studies have, in the main, concentrated on urban, wage-earning families rather than including all income and occupational groups in the population. Seven of the twelve countries whose sampling methods have been published have used random sampling techniques; nine of the twelve countries have used the account book method of data collection. Six of the countries have remunerated the participating families.

The study currently being carried out by the European Coal and Steel Community, which is attempting to employ the same techniques for the collection of consumption expenditures, incomes and prices in the six member countries during the same time period, will be watched with interest by all students of consumption economics.

NOTES

A NOMOGRAM FOR PRICING PRODUCTS WHOSE RELATIVE SUPPLIES ARE FIXED BY THE YIELDS FROM A PARENT SOURCE*

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STUDIES of retail self-service piece-chicken displays in West Virginia have shown that only rarely were all the different fryer parts concurrently available to the shopper. Analyses of stores showed that the few large super markets that order fryer parts from a central point usually had more complete displays than did the stores that rely entirely on cutting out all their piece chicken in the store.

Food chains, regardless of whether piece chicken is cut out in the store or ordered from a central point, set prices for the different parts at a central point—such as at a branch or division office. One of the prime reasons for the central-point pricing is that the chain management wants to maintain a specified weighted-average price for piece chicken as a whole. Maintaining an "over-all" mark-up (or weighted-average price) is certainly an onerous and not-too-well-handled task even though it is not of recent origin. Chain managements evidently feel that this task cannot be entrusted to local store managers.

To cope with the problems of pricing fryer parts relative to each other, a detailed study was made for 499 continuous store hours in one of West Virginia's outstanding stores. The initial objective of this work was to determine indices of cross-elasticities of demand among the fryer parts. The assumption was that these indexes could be the primary guides to the central-point pricing in the food-chain organizations.

Even though several tons of piece chicken were studied and sold in this study, the findings were only of a negative nature. One conclusion drawn was that—if reasonably stable cross-elasticities do exist—it would be a tremendously expensive research task to determine anything accurate enough to be of functional value to the trade. The second conclusion drawn, from this along with other studies, was that central-point pricing of piece chicken should be abandoned, unless there is also central-point cutting so that supplies could be allocated to different stores according to demand in response to the central-point pricing. The reason for this second conclusion is that the relative demand for the different pieces of chicken seems very unstable both distance-wise and time-wise.

* Approved by the Director of West Virginia Agricultural Experiment Station as Scientific Paper No. 524.

It seemed logical that food-chain managements would not entrust this type of weighted-average pricing to local management unless a system could be worked out that would be relatively foolproof from both the standpoint of operation and inspection. After several types of possible pricing aids were investigated, the "Pricing Wheel" shown in Figure 1 was applied to the problem.

The pricing wheel is simple both in theory and in operation. The scales on the circumferences for the different parts are so chosen that the price indicated on one fryer part multiplied by the average percentage yield of this part from whole birds results in a product equal to any other price (along the same radius) times its average percentage yield. This was ac-

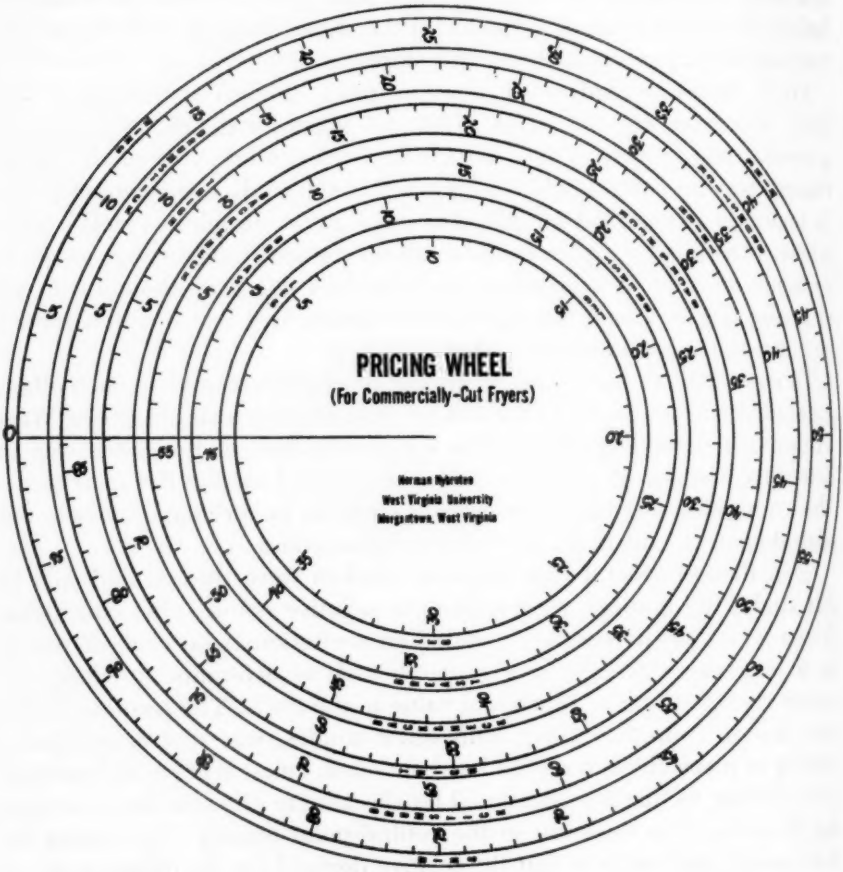

FIG. 1. A NOMOGRAM FOR PRICING CHICKEN FRYER PARTS RELATIVELY IN RESPONSE TO CHANGING DEMAND WITH RELATIVE SUPPLIES AS YIELDED BY THE FRYER ANATOMY BY THE COMMERCIAL-CUT METHOD.

complished by using reciprocals of yield percentages for the individual scales. For example, if the wheel in Figure 1 is turned to 25 cents on wing the radius will fall on 10 cents for leg. This means that a 25-cent change in the price of wing will have about the same effect on gross revenue as a 10-cent change in the price of leg. One hundred pounds of commercially-cut fryer yielded 31.2 pounds of leg and 12.4 pounds of wing. The wheel would check thus—10x31.2 = 312 = 25x12.4 = 310. The slight difference between the two is the result of mechanical inaccuracy and rounding off numbers to whole cents.[1]

The use of a pricing wheel of this type is not limited to piece chicken. There are many problems similar to this in pricing cuts of meats from other animals. This is not limited to retail pricing and may apply to products other than meat.

Although this nomogram seems to have a rather widespread potential use, and would simplify an otherwise complex problem, there are some obstacles in its way. Research on the use of the pricing wheel shows that heads of meat departments are reluctant to change prices even if the changes come this close to being automatic. They are prone not to change prices early enough to prevent malsupplies from developing. One reason for this is that, under present methods of placing retail price tags on meat, a number of meat packages would usually need to be re-wrapped as well as re-priced in order to make the pricing wheel an effective aid in responding to quickly changing estimates of demand conditions.[2] The specific "pricing wheel" in Figure 1, however, will not universally fit all conditions for commercially-cut fryer parts. Although a large amount of research was done to make this fit actual conditions, and very little difference was found among breeds of fryers, advisers to the trade should study cut-out yields before they assume they have a final answer.

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[1] For a more detailed explanation of the pricing wheel, see W.Va. Ag. Exp. Sta. Bul. No. 385, *Pricing Piece Chicken for Kept-up Displays.*

[2] The West Virginia Agricultural Experiment Station is initiating research on the problem of price-tagging meat. Perhaps this reluctance can be overcome through proper information and proper incentives.

ECONOMIC INFLUENCES ON LIVESTOCK NUMBERS IN NEW ZEALAND, 1920-1950

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IN NEW ZEALAND the farming sector usually accounts for about a third of net national income and is virtually the sole source of the foreign exchange that is indispensable to a country lacking many foodstuffs and most industrial raw materials. Fluctuations in the volume of primary production are, accordingly, of major consequence to the whole economy. The most important farm products and practically the whole of farm exports are derived from livestock—dairy products, meat and wool. The outputs of these are, however, affected not only by economic influences but also by climatic, technological and other factors. We, therefore, examine movements in livestock numbers rather than in the outputs derived from them and consider each main livestock series separately in order to throw the economic influences into the strongest possible relief for, if economic factors do affect outputs of farm products, their direct effect is presumably to influence farmers' decisions about numbers and types of livestock to be raised. The analysis is restricted to the period 1920-50 because adequate economic data are not available earlier than 1920 and because of changes in the date of collection and coverage of the official censuses of livestock in 1951.

Each livestock series is analysed using a single-equation model of the form

$$\log X_t = \log A + \Sigma\, b_i \log P_{i,\, t-d_i} + ct + U_t$$

in which X_t denotes the size of the livestock population in year t; the $P_{i,\, t-d_i}$ economic variables d_i years earlier; t is trend and U_t residual variation. Logarithms are used partly because they give a better fit and partly because of the immediate identification of the b_i with elasticities. All the economic variables are expressed in real terms, i.e., deflated prices, income or cost series or ratios of prices. The lags appear because the production process for livestock is generally long. The basic hypothesis of this study is that economic factors account for most of the observed variation in livestock numbers. The residual variation may be attributed to technological, climatic and other influences. The former may be important in some years (e.g. shortage of fertilizers in the early nineteen-forties) but are unlikely to prevent the isolation of economic factors. Climatic factors are, however, often asserted to be major causes of fluctuations in farm production. Our view, on the contrary, is that they

* This study owes a great deal to the advice and encouragement of Professor C. G. F. Simkin, of Auckland University College.

have relatively little influence on livestock numbers. The two claims are, however, not necessarily incompatible as an example will show. Droughts in New Zealand are seldom severe enough to affect dairy cow numbers although they have marked effects on butterfat production. The presence of a trend term in the model is less easy to defend; but it is necessary to account for the long-run tendency of many New Zealand livestock series to increase notwithstanding adverse economic conditions. Trend is probably connected with the inadequacy of cash receipts as an index of farmers' incomes in times of low prices. The trend term may also arise partly from slow technological advances in carrying capacity of New Zealand farms.

The model is in a form permitting the statistical estimates of the parameters to be properly assigned to the appropriate variables, for the explanatory variables are all predetermined and the independence of U_t and $P_{i,\ t-d_i}$ may be granted. Furthermore the model is such that least-squares methods of estimation may be used. In view of the well-known danger of statistical regressions acquiring a spurious accuracy through the introduction of a large number of variables, it is necessary to make a preliminary selection of possible regressors in applying the model to particular livestock populations. Preferably this is done by using the general knowledge of farming practices, particularly with respect to the economic alternatives open to the farmer. Such knowledge may be supplemented to some extent by "graphical reconnaissance" and by examining the simple correlation coefficients. In determining appropriate lags, emphasis was placed on biological considerations, supplemented to some extent by graphic analysis. Then follows multiple correlation analysis leading to regression equations, the usefulness of which may be judged by the criteria of goodness of fit (multiple correlation coefficient), absence of multicollinearity (bunch map analysis[1]), serial independence of residuals (von Neumann ratio), and significance of estimates of parameters (standard errors). Regression equations that fail to satisfy all these criteria may, however, be useful for some purposes, e.g., for prediction when the coefficient of multiple correlation is high.

The regressions finally obtained are summarized as follows:

Notes:

(1) This is a more accurate measure of lamb numbers than births because it excludes the rather large number of lambs that die shortly after birth.

(2) As nearly all sheep are shorn this is an accurate measure of sheep numbers.

(3) The use of this ratio is suggested by the fact that beef cattle are almost exclusively grazed in conjunction with sheep.

(4) The lamb, mutton and beef price series are unit export values. Wool price is the official index. Butterfat prices are average factory payouts. Dairy returns are

[1] All the regressions shown below give rise to satisfactory bunch maps.

SUMMARY OF RESULTS

Dependent Variable	Explanatory Variable	Lag d	Multiple Correlation Coefficient R	Von Neumann Ratio v	Elasticity or Trend Coefficient (6) b or c	Standard Error (6)
Lambs tailed (1)	Lamb to mutton price ratio	1	0.98	0.83	+0.34	0.06
Lambs tailed	Time	—			+9.8	1.3
Sheep shorn (2)	Lamb -to wool price ratio	2	0.80	0.86	−0.24	0.06
Sheep shorn	Lamb to mutton price ratio	2			+0.87	0.11
Sheep shorn	Mutton to wool price ratio	2	0.99	1.54	−0.19	0.01
Sheep shorn	Time	—			+5.4	0.2
Beef cows	Beef price to dairy return ratio	4	0.98	1.13	+0.29	0.03
Beef cows	Time	—			+8.3	0.4
Ratio of beef cows to sheep shorn (3)	Beef to wool price raratio	4	0.90	1.77	+0.29	0.03
	Real beef price	2			+0.22	0.04
Steers	Real beef price	4	0.88	1.42	+0.48	0.03
Total beef cattle	Beef price to dairy return ratio	4	0.95	1.21	+0.17	0.03
Total beef cattle	Time	—			+5.0	0.4
Dairy cows	Real gross dairy income	2	0.86	1.95	−0.12	0.02
Dairy cows	Real farm costs	2			+0.26	0.03
Pigs	Real gross dairy income	(5) 0	0.96	2.12	+0.90	0.08
Pigs	Real butterfat price	2			−0.46	0.06

butterfat prices multiplied by average production per cow; thus they represent average returns per cow. Gross dairy income and farm costs are the official estimates. The deflator in every case is the general (retail) price index.

(5) The absence of a lag here does not result in loss of identification as pig production is a sideline of dairy farmers and receipts from the sale of pigs form a negligible part of gross dairy income.

(6) As these analyses were run in logarithms, the trend coefficients and their respectve standard errors are preceded by a number of zeros to the right of the decimal point. To save space in the table, these factors are multiplied by 1,000.

A number of economic influences on livestock populations have been isolated in this study and their importance should be considerable. Since nearly all New Zealand farm production is derived from livestock, we have also, indirectly, established the importance of economic factors in determining aggregate farm production. For although several residuals

are highly auto-correlated, in only one case are the estimates of parameters less than five times their respective standard errors so that we may feel fairly confident of the significance of the estimates.[2] The economic implications of our results are all reasonable. In the case of lambs we see that a rise in lamb prices tends to encourage more lambs in the next season whereas a rise in mutton price has the opposite effect presumably because higher mutton prices lead to heavier cullings of sheep and hence fewer lambs one year later. Sheep numbers tend (after a two-year lag) to vary directly with lamb and wool prices and inversely with mutton prices. These results are obviously reasonable. In the case of beef production we find that beef price has a direct connexion with cattle numbers and that there is some indication of a tendency to substitute beef cattle for dairy cows or sheep. As beef grazing is the easiest type of farming of all, this is not hard to accept. The longer lags for beef cattle as compared with sheep are to be expected, in view of the longer time taken by beef animals to reach maturity. In the case of dairy cows there is evidence of a negative income effect probably because dairy farming is more onerous than pastoral farming so that when incomes are high dairy farmers tend to switch over to sheep. (Also in good times they can better afford this, especially as capital requirements are higher in pastoral farming.) With pigs the likely reason for less production when dairy farmers are receiving good prices is simply that the keeping of pigs is regarded as a nuisance. The positive income coefficient is to be interpreted as a short-run effect only.

[2] H. Wold, *Demand Analysis*, p. 44.

FREE CHOICE VERSUS LEAST-COST MIXED RATIONS FOR HOGS

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PRODUCTION functions derived for one purpose often have other practical uses, too. For example, empirically derived hog production functions have been presented.[1] What is the practical significance of these production coefficients? Obviously, farmers who always feed a ground and mixed ration would profit by selecting the "least-cost" ration or mix. However, the problem is more complicated if the farmer has the opportunity of feeding a protein supplement free choice along with shelled or ear corn. Although the hogs might not select the cheap-

[1] Earl O. Heady, Roger C. Woodworth, Damon Catron, and Gordon C. Ashton, "An Experiment to Derive Productivity and Substitution Coefficients in Pork Output," *Journal of Farm Economics*, Vol. XXXV, No. 3, August 1953, pp. 341-354.

est combination of protein and corn, it still might be cheaper to feed them free choice because of the saving of grinding and mixing costs.

A possible solution to this problem can be derived from the production function itself. Since the most appropriate algebraic form of hog-response function has not been unanimously agreed upon, solutions are presented for both the quadratic function (1), and the Cobb-Douglas over-all function (2).[2]

$$(1)\quad Y = 2.032 + 0.324\ C + 0.464\ S - 0.000129\ C^2 - 0.000917\ S^2 - 0.000111\ CS.$$

$$(2)\quad Y = 1.360\ C^{.630}S^{.201}.$$

To determine the feasibility of free choice versus controlled rations, the cheapest controlled ration is determined for producing a specified amount of pork. Since hogs are generally expected to overeat on protein supplement, the greatest gain from "controlling" the ration would occur where soybean meal is expensive relative to corn. In 1948, soybean meal averaged about \$5.02 per cwt. as compared with \$2.32 per cwt. for corn. The soybean-meal-corn price ratio was 2.2 which is considerably higher than the other postwar years. Therefore, 1948 prices were the most favorable for controlled rations in recent years.[3] If grinding corn costs \$0.10 per cwt., mixing costs \$0.10 per cwt. of feed mixed, and aureomycin and other supplement adds \$0.40 per cwt. to the cost of soybean meal, then the appropriate soybean-meal–corn price ratio for the "controlled" ration is $5.52/2.52 = 2.190$. In this case \$0.10 per cwt. is assessed equally against both corn and soybean meal for mixing. Actual grinding and mixing costs may often differ from those assumed in this example. Grinding and mixing costs in this case are favorable for controlled feeding.

According to the quadratic function (1), 200 lb. hogs can be produced most cheaply by finding the intersection of the 200 lb. hog isoquant (which is 160 lbs. gain after weaning at 40 lbs.) by the least-cost ration line. The least-cost ration line where soybean meal is 2.190 times the price of corn per cwt. is given in Fig. 1. The intersection of the 200 lb. hog isoquant by the least-cost ration line represents an input of about 31 lbs. of soybean meal and about 590 lbs. of corn.[4] The cost of this ration

[2] *Ibid.* Increase in hog weight after weaning is denoted by Y, pounds of corn by C, and pounds of protein supplement (soybean meal) by S. (Protein supplement was denoted by P in the original article.)

[3] U. S. Department of Agriculture, *Crops and Markets*, Vol. 30, U. S. Government Printing Office, 1953 Ed.

[4] The least-cost line represents points of tangency of budget lines with the isoquants. Budget lines show the various combinations of factors which can be purchased and used with a fixed amount of money for a given technique of production. The equation of the least cost line is found from (1) by setting the partial derivatives of Y with respect to S and C equal to the soybean-meal–corn price ratio.

$$\partial Y/\partial S / \partial Y/\partial C = P_s/P_c$$

The intersection of the least cost line with the isoquant gives the same result as

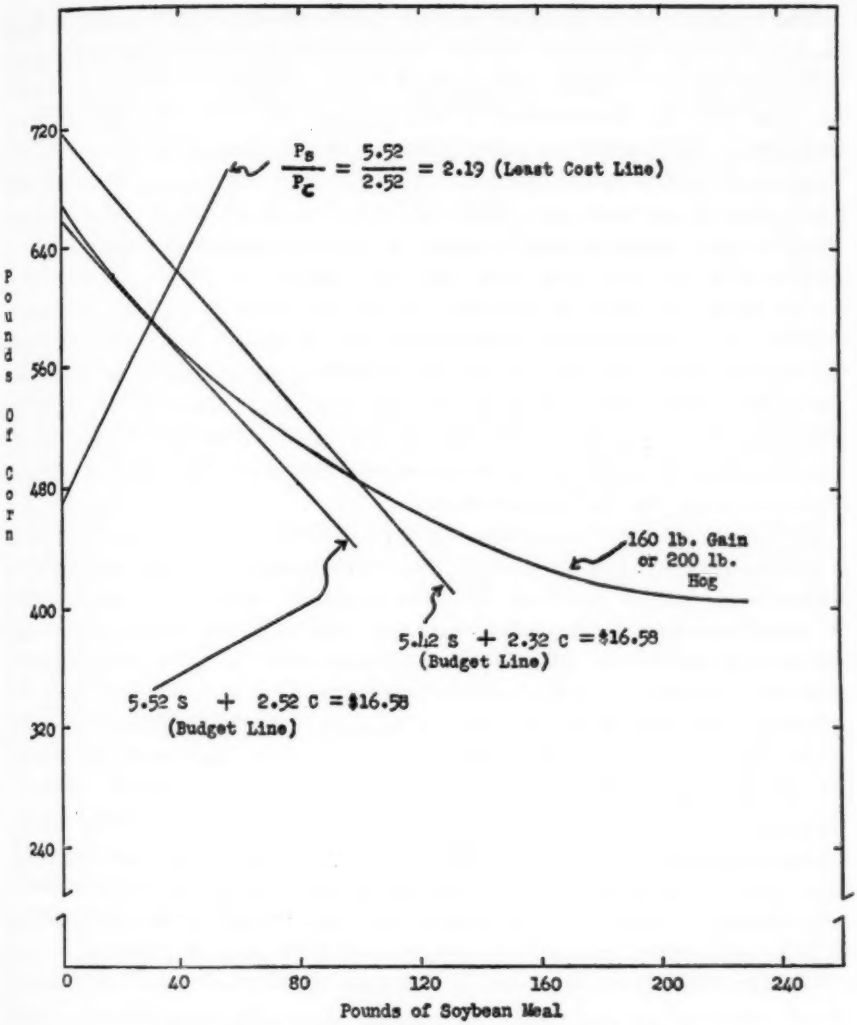

FIG. 1. BREAKEVEN POINT FOR QUADRATIC FUNCTION.

is $16.58 (which is the minimum cost for a ground and mixed ration under the assumed prices). However, $16.58 will purchase more feed if the cost of grinding and mixing is not incurred. For example, in Fig. 1, 640.9 lbs. of corn can be purchased along with 31 lbs. of protein supplement under free choice feeding; the cost of corn would be reduced from $2.52 per cwt. to $2.32 and soybean meal would be reduced from $5.52 to $5.42.

finding the point of tangency of the budget line with the isoquant. However, it is much easier to determine the point of intersection than the point of tangency.

The amounts of feed which can be purchased by \$16.58 under a free choice feeding operation can be represented by the linear equation, 5.42 S + 2.32 C = \$16.58. This budget line is also shown in Fig. 1. It can be seen that the intersection of the budget line with the 200 lb. hog isoquant is the break-even point between self-feeding and the controlled "least-cost" ration which incurred grinding and mixing costs. (If hogs under free choice ate more than 99 lbs. of soybean meal, the cost per 100 lbs. gain would be higher because lower isoquants would be intersected. Hog weights less than 200 lbs. would be obtained from the \$16.58 worth of feed.) If the hogs which are fed free choice can reach 200 lbs. on a ration which does not exceed 99 lbs. of soybean meal and 483 lbs. of corn, self-feeding will be equally or more profitable than the controlled "least cost" ration. If the hog eats more than 99 lbs. of supplement before reaching 200 lbs. (if the ration exceeds 13.6 percent protein), then it would be more profitable to control the ration by grinding and mixing the "least-cost" ration.

For other cases where soybean meal is relatively less expensive compared to corn, hogs fed free choice could consume larger amounts of protein supplement and still be more profitable than hogs on the controlled "least-cost" ration. For example, the soybean-meal–corn price ratios averaged about 4.50/2.60 = 1.73 from 1946 to 1951.[5] If \$0.40 per cwt. for vitamins is added to the soybean meal price plus \$0.10 for grinding corn and \$0.10 per cwt. for mixing, the appropriate price ratio would be 5.00/2.80 = 1.786. This least-cost ration line would intersect the 200 lb. hog isocline at 49 lbs. of soybean meal and 556 lbs. of corn. However, with free choice feeding the cost of grinding and mixing would be avoided; hogs would reach 200 lbs. as or more cheaply by selecting their own ration if they did not eat more than 128 lbs. of soybean meal and 452 lbs. of corn. In other words, the hogs should be fed free choice if their self-chosen ration does not exceed 15.5 percent protein.[6]

For the Cobb-Douglas over-all function, the "break-even" points between self-feeding and controlled rations are again found by the same procedure. For example, assume corn is again \$2.60 per cwt. before grinding and mixing and supplemented soybean meal is \$4.90 before mixing. The appropriate soybean-meal–corn price ratio for "controlled" rations is 5.00/2.80 when grinding and mixing costs are added. The

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[5] *Crops and Markets, loc. cit.*

[6] The results of this analysis assume that a given amount of feed produces the same gain, whether consumed by a hog on a free choice or controlled ration. However, the same procedure could also be used if two methods of feeding (or techniques) were known to differ in efficiency by a given percentage.

It should also be noted that in some cases the percent protein limits determined would be affected by the isoquant values assumed.

optimum means of achieving 200 lb. hogs (160 lbs. after weaning) from equation (2) is given by (3).

$$(3)\quad dC/dS = (117.647)^{1.58730}\ (-0.31905)\ S^{-1.31905} = -5.00/2.80.$$

Solving (3), optimum inputs of about 84.1 lbs. of soybean meal and 470.5 lbs. of corn are indicated. However, if grinding and mixing costs can be avoided by self-feeding protein, 200 lb. weights can be achieved just as cheaply by either 41 lbs. of soybean meal and 591 lbs. of corn or by 144.5 lbs. of soybean meal and 396 lbs. of corn. (A lower limit for soybean meal as well as an upper limit is indicated by the above solution because of the greater factor complementarity imposed by the Cobb-Douglas function.) These soybean meal limits would indicate that free choice feeding was equally or more economical than the controlled "least-cost" ration if the hogs on free choice did not eat less than a 9.7 percent protein ration or more than a 17.3 percent protein ration.[7]

The quadratic function, (1), placed a lower ceiling on soybean meal consumption for the self-fed hogs than did the other functions. How well would hogs stay within the protein percentage limit indicated by the quadratic function? Experiments in Kansas with soybean meal fed free choice to hogs in dry lot averaged between 13.7 and 14.1 percent protein.[8] These rations fall outside the quadratic limit of 13.6 percent for 1948 prices but well within the limit of 15.5 percent for average prices of 1946 to 1951. Of course, other experiments might show different percent protein rations for free choice feeding.

Conclusions

Conclusions from this preliminary analysis are based on the assumption that the efficiency of gain is the same for hogs on free choice as on controlled rations. That is, a given combination of corn and soybean meal is assumed to produce the same gain if selected by a hog free choice as the same amount and combination of corn and soybean meal fed to a hog on a mixed and ground ration.

Free choice feeding appears to be as economical as a controlled ration if grinding and mixing costs are 10 percent or more of the cost of corn per cwt. However, if soybean meal is unusually expensive relative to corn, say 2 to 2.5 times the price of corn per lb., then grinding and mixing costs could be 10 to 15 percent of the corn price before free

[7] "Break-even" points between free choice and controlled rations for the interval Cobb-Douglas functions appeared to fall between those given for the quadratic and the over-all Cobb-Douglas. However, due to insufficient information regarding the interval estimation, these results were more difficult to check and are not presented.

[8] C. R. Aubel, *Swine Feeding Investigations*, Kansas Agr. Exp. Sta. Circ. 207, Manhattan, Kan., June, 1941.

choice feeding would be favored. In such cases where grinding, mixing, and handling costs for controlled rations are high, some alternative to grinding the corn and mixing it with supplement might be feasible. For example, increased mineral or alfalfa meal mixed with soybean meal might discourage overeating of supplement. Hand feeding of soybean meal might be another possibility under certain conditions. Further empirical work is obviously needed to obtain satisfactory answers to many of these practical problems. Further research would seem to be fundamental for progress in this area.

BENEFITS VERSUS COSTS OF PRICE SUPPORTS

Reply to Criticism of Anthony Y. C. Koo

A FEW comments relating to Mr. Koo's criticism, published in *Journal of Farm Economics* (Vol. 27, No. 4, No. 1955), of my paper on "Benefits Versus Cost of Price Supports," published in *Quarterly Journal of Economics* (Vol. 68, No. 1, Feb. 1954), may be in order. Mr. Koo stated that, "The essence of the criticism is that the indifference diagram approach makes no overt reference to marginal costs, yet we know that the case against indirect taxation is merely a special case of conflict with one of the necessary conditions for the achievement of a Pareto 'optimum,' namely, relative marginal cost be equal to relative prices."

The only segment of my paper to which Mr. Koo directed his criticism was expressly limited to short-time results concerning which the problem of achieving an "optimum" with relative marginal cost equal to relative prices obviously was not involved. Consequently, Mr. Koo's criticism, regardless of whether it is valid as applied to the indifference diagram approach in evaluating the influence of direct and indirect taxation, under the conditions which he apparently assumed, is irrelevant. Furthermore, my main conclusions relating to price support and direct payment programs would hold, even without the support of the segment to which Mr. Koo referred.

Since Mr. Koo's criticism is irrelevant and since the main theme of my paper would hold, even if his criticism had been valid, it would appear that Mr. Koo's conclusion that, "Howell's arguments against price supports cannot be established as a general case on theoretical ground," is not sustained. My purpose was not to argue for or against price supports, but rather to present objectively the results of my analysis to show the relative amounts and distribution of the benefits and costs, in terms of dollar evaluations, of price support and direct payment programs for agricultural products.

L. D. Howell

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REVIEWS

Land Tenure, Edited by Kenneth H. Parsons, Raymond J. Penn and Phillip M. Raup, Madison: University of Wisconsin Press 1956, Pp. xxiv, 739. $10.00.

Land tenure is one of the most pressing political problems in the world today. And this volume is an invaluable text for its study.

The book is the product of the International Conference on Land Tenure and Related Problems in World Agriculture held at the University of Wisconsin in 1951. Some 40 countries were represented. The chapters in the book are in main the papers read at the general sessions, though a few were added later from the seminars of the conference.

This volume offers a serious and significant contribution from each of the critical areas of the world. One who wants to know the land tenure problem in the Philippines, Pakistan, India, Chile, Burma or dozens of other countries can find an account here. There are even accounts of land tenure problems in Russia. But the Russian account is not as authoritative as some of the others, since what we knew about Soviet farms in 1951 was largely from secondary sources. Even so, the writers on Soviet collective farms show great discernment. The state farms, however, are emerging more prominently than these articles would suggest; and the role of the private farm plots is much greater than these 1951 papers make out. At least, that was my impression from my Russian journey in 1955.

It is also my belief that the account of land tenure in Iran is only a partial one that unwittingly tends to mislead. This account magnifies the program of the Shah in distributing royal lands to the peasants. That program is an important one. I have seen some of the new Iranian villages that are the product of it. In those villages one finds the seeds of the first village democracy Iran has ever known. But the royal lands make up only a small percentage of Iran's farm lands. The account does not show the abject misery in which the bulk of the farm population lives. It does not show how rent plus interest on loans eats up most of the substance, leaving little for the tenant. Thousands of Iranian peasants have incomes that do not total more than a few dollars a month. The agricultural environment is one of oppression. There are no schools, no hospitals, no doctors in the rural villages. Generation after generation is born to filth and misery. The landlord is the moneylender as well; and he often exacts blood money. He often owns hundreds of villages and lives in luxury in Paris or Beirut. But his tenants live in hovels with no hope of emancipation.

Parts of the presentation of the land tenure problems in this book are,

therefore, superficial. But over all, the volume has a breadth and a depth that presents the issues in true perspective.

The world account is not all on the minus side. The constructive efforts made in some countries—notably Japan and India—to make a fair distribution of land among the farmers are real pluses. Yet the solution of the land problem is not necessarily the distribution of large holdings to the tenants or share croppers. At times, the holdings that result are so fragmentized as to be uneconomical as producing units. Small units need to be pooled and farmed as an entity, if the advantages of modern agricultural methods are to be attained. The choice between the collective farm and the cooperative is offered the world—with the collective receiving very few adherents.

The book by inference at least teaches an important lesson—that tenancy reform is at best a dubious palliative, that if there is to be a true democratic base in a nation, the land must be broadly distributed.

Break up of the great estates is often necessary if the nation's program of industrialization is to go forward. Capital needs to be taken out of the land and put into industry. No more striking example exists anywhere than in the Philippines.

The population problem, which these addresses properly stress, also indicates that pressure must be taken off the land, that men must turn to the handicrafts and to the mills for a livelihood. The land problem and the population problem are indeed faces of the same coin.

Once land is distributed to the farmers, a new educational program is necessary. Sharecroppers have been utterly dependent on the landlord for what to plant and when to harvest. Once free of landlord control they are on their own. They need education and a growing confidence in their ability to be independent. Instruments for agricultural credit must be created. Distribution of the big estates among the tenants is in other words the beginning not the end. Yet without it, no real advance in democratic traditions can be made. Democracy starts with the land but it does not end there.

The problem of land distribution is so massive a one in some nations that "just compensation" in the American sense cannot be made to the landlords. The wealth of the nation would not permit it. The problem of paying what the nation can and yet avoiding confiscation is an acute political problem in several areas.

Great portions of the world are still under the yoke of feudalism. No more impressive document has been produced to demonstrate it than this one. A reading of this volume shows how far the world must go to fulfill the democratic ideal even in farming. It poses the great question whether democratic processes or the communist way will win out. One

great sector of the struggle will be around the problem of land tenure. For that reason the book is a timely one. It is, indeed, the most valuable reference book that one can find on the subject. The faculty of the University of Wisconsin is to be congratulated on having conceived the project and having carried it through in this pre-eminent manner.

WILLIAM O. DOUGLAS

Supreme Court of the United States

Can We Solve the Farm Problem? Murray R. Benedict, New York: The Twentieth Century Fund, 1955. Pp. xix, 601. $5.00.

This is the key volume in Professor Benedict's ambitious study of farm policy—a study which began several years ago as an independent scholarly enterprise and which in recent times has been adopted and supported by the Twentieth Century Fund. The first volume, *Farm Policies of the United States, 1790-1950,* was frankly historical. A forthcoming volume, of which Dr. O. C. Stine will be co-author, will deal with the lesser policy on individual commodities. This present volume was intended to view farm policy in the large and to answer the large question posed in its title. In addition to the main section of the volume by Professor Benedict there is a further chapter devoted explicitly to recommendations on farm policy. This is the work of a committee of agricultural economists and specialists and farm leaders which was established under the chairmanship of Mr. Jesse Tapp, Chairman of the Board of the Bank of America. The two parts of the book must be reviewed separately.

I

Although Professor Benedict's part of the volume is much the more important, one reads it with some disappointment. History, it is plain, can be a master as well as a servant and in this volume it has the upper hand. Much too much of the volume is devoted to a meticulous chronicle of legislative and administrative action and far too little to an analysis of the consequences and to the lessons for the future. This would not be a proper matter for complaint—it is Professor Benedict's privilege to write history if he prefers and he is a good historian—except that it takes him over ground that he has already covered in his earlier volume. And it has diverted energy and attention from the announced task which was to seek an escape from the present *impasse* in farm policy, or at least to provide the lessons which would guide others in the search.

Not that the volume is devoid of analysis. The author begins with an examination of the special features of agriculture in the economy and

the factors which comprise the farm "problem." In subsequent chapters on research and education, the Farm Board experience, credit policy, early production control and price support techniques, subsidies and surplus disposal, conservation, loan and purchase operations and in a final chapter on the lessons of the last twenty years he pauses at intervals to assess the experience. But the assessment is almost lost in the far more extended account of what happened. At no time, moreover, is there a good indication of the criteria by which the author measures success or failure. He has an insistent preoccupation with the costs of the programs to the government. On occasion he comes perilously close to implying that if the cost was small the program was good. Obviously, in a mature view of the Federal Farm Board experience, large losses on stabilization operations could be taken to signify a serious effort to stem the deflation in farm prices and incomes. No losses would mean only that the Board did nothing. The Farmer's Home Administration does not lose money on its tenant purchase loans. This means only that its accomplishments are imperceptible. In other circumstances of course public costs mean wasted resources.

There are other difficulties. Professor Benedict is reasonably eclectic in his use of economic ideas. He comes close at times to conceding the possibility of a long-run disequilibrium in the income relationships between agriculture and the rest of the economy. Structural differences between agricultural market relationships on the one hand and those of business or the unions of the other are admitted. These in turn lead to differing responses to changes in demand and particularly to the possibility of strongly adverse movements in the farmer's terms of trade. But Professor Benedict accepts without incorporating. In the end he largely assumes that the price system will work things out and that the equilibrium which it establishes will, on the whole, be the best the farmer can expect. This assumption is never quite explicit; on occasion it is even questioned. But it rules and as always its rule is formidable. If the economically optimal equilibrium is normal then adjustment will always be in progress. In Professor Benedict's system a desirable adjustment is always a matter of time. Accordingly there is basic presumption against interference; it can only accomplish what is being done anyway and there is always a chance that it may serve to impede the adjustment.

This does not lead Professor Benedict to advocate a return to the unhampered price system. He is too realistic for that. However his framework keeps him from seeking to improve boldly on the massive structure of government market interference which he describes. In the end—one senses rather thankfully—he turns over the task of prescribing to the Committee which was constituted to make recommendations.

II

Were one to list the economic principles and attitudes which, on matters of farm policy, have reduced the once-influential profession of agricultural economics to the role of neglected scolds, there would perhaps be four. Younger members of the profession may wish to put them under the glass tops of their desks as a guide to the accepted code of behavior. They are:

1) Always identify conservatism with wisdom.
2) Accept the uninhibited price system as a social and scientific norm.
3) Avoid controversy at all costs.
4) If the foregoing rules do not apply advocate more research.

The Committee which the Twentieth Century Fund established to make recommendations on agricultural policy has at least the virtue of having provided a classic example of the application of these rules.[1] It is not an incompetent report. As the influence of the agricultural economists has dwindled on policy matters there has been a not unnatural tendency to seek compensation by resort to numbers. Collective pronouncements on farm policy have become commonplace. This one is up to, and probably above, the level of its competitors. Unlike the unfortunate *Searchlight on Agriculture* it proclaims no deathless though somewhat self-contradictory principles. It differentiates between the problems of different commodities and in the case of wheat between different types. On occasion it advocates the temporary use of production controls or price supports. While in accordance with Rule 1 above, it offers no new proposals for dealing with the problem of surpluses, in keeping with the same rule it advises caution in the retreat from what is now being done.

Nonetheless the ultimate remedy is to lower prices to the point where markets are cleared. Although in the case of some products this recommendation is reached circuitously it is, in the end, the all but invariable cure. (Rule 2.) Generally speaking it is not an objection that this remedy is unacceptable to the farmers involved. In the case of butter, however, the Committee was unwilling to recommend the reduction that would then seemingly have been required. Its formula: "We suggest careful exploration of the possibility of providing, in the primary butter-producing areas, a declining direct-payment program which would aid butter

[1] More precisely those who concurred. Two members, Quentin Reynolds and Theodore Schultz, protested at intervals against what they believed to be recommendations for undue or unwise government interference with the price system. One member, John D. Black, thought the Committee failed to go far enough in important particulars and otherwise dissented. Two other members of the twelve-member Committee rejected the report as inadequate in its entirety. Another expressed general discontent with its comprehensions of the needs and problems of the family farm.

producers during the time adjustments are being made." (Rules 1, 2, 3 and 4.)

For the Committee the farm problem consists almost entirely in finding out how the government can detach itself from its present surplus stocks and avoid future involvement. The relative or absolute level of farm income attracts no sustained attention nor does the question of its reliability. These preoccupations of farmers, though not dismissed, are treated with scant sympathy. There are routine gestures of interest in the problems of poor farmers and tenants but no hint of compassion. Recommendations are minimal; there is no suggestion that the problems of agricultural poverty or unsatisfactory tenancy should be attacked on a scale appropriate to their solution. Landless workers who, in the aggregate, must account for a large part of the discomfort and suffering in our agriculture—and who in this rather significant sense are the farm problem—are not mentioned.

These are the attitudes which have reduced agricultural economists to a nullity as far as agricultural policy is concerned. They assume that the price system is nondiscriminatory in its application to different economic groups or even though slightly discriminatory, that it is an acceptable norm. No available alternative, in any case, is considered; none has the authority, refinement, precision and respectability of the uninhibited price system. But what is a matter of intellectual motivation for economists is a matter of livelihood for the farmers. They cannot afford the risk of the economist's model. As I have pointed out before, the reaction of the trade unionists during the last century and much of this, when they were advised by orthodox economists to dissolve their unions in the interest of free competition, was much the same. So long as labor economists gave this advice they naturally had little influence on policy and collective bargaining procedures. It should surprise no one that so long as agricultural economists meet in committees to resolve to return the farmer to the free market they can have nothing influential to say about how farm programs should be designed and operated.

This is admirably illustrated by the present report. The three men whose identification is most directly with agriculture—two farm organization leaders and the editor of a leading farm paper—found the proposals either inadequate or totally unacceptable. On the other hand they were unable, without the help of the economists, to formulate an alternative program of their own. Evidently this did not perturb the economists. Yet they would be perturbed to find these men advocating the present program with all its faults. Yet this is the only recourse of the layman as it is the principal present recourse of farm leaders, politicians and others who must have an effective program and who are

getting no help in formulating one. The blame for the present unhealthy state of farm policy is thus squarely at the door of those, who, in the name of conservatism, caution, or the sanctity of the price system, decline to think in terms of what the farmers can accept. These are hard words but they cannot be said with too much clarity.

J. K. GALBRAITH

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Experimental Design, Walter T. Federer. New York: The Macmillan Company, 1955, Pp. ix, 544, 47. $11.00.

Two powerful, not unrelated, forces are at work simultaneously supplying the current market and creating a new one for accounts of what it known concerning the theory and practice of the design of experiments: The modern theory is only about 30 years old although the method of least squares on which most analysis is based dates back to about 1800. Agriculture and biometrics have undoubtedly made the most extensive use and development of the method of variance analysis introduced by R. A. Fisher. Recently, however, there has been an upsurge in the demands by industry, the physical science research laboratories, marketing researchers and many other disciplines for new and better design and analysis procedures as well as for more readable accounts of those procedures that have already proven themselves in other fields. Since the appearance of Cochran and Cox's *Experimental Designs* in 1950 (John Wiley and Sons), a rash of books has been published, a few excellent, some good, others quite mediocre. At the same time rapid developments are being made, not outmoding earlier techniques but rather only outdating by way of complete coverage comparatively recent books on the subject. A few of the recent textbooks have been so written that the interested reader may learn not only how to design and analyze experiments suited to his purpose but also why they are suited to his purpose. From more of them most readers will learn only how to analyze rather than why and consequently won't learn much about how actually to design experiments. Dr. Federer has now added an up-to-date and unusually comprehensive compendium of what is known about experimental design and analysis and where to look to find it. It was the author's intention to bring together for comprehensive coverage in a single volume widely scattered, known facts concerning experimental design. The reviewer's opinion is that more of the readers of this *Journal* will be impressed by (or should I say deluged?) than will comprehend the coverage. This is not to say that the book is not a good one; it is. But, again in the reviewer's opinion, it assumes on the part of the reader

too much familiarity with the mathematics and analysis of design for beginners but also fails to provide the necessary motivation for one adequately equipped.

A number of books the author recommends, for example, E. B. Wilson's *An Introduction to Scientific Research,* McGraw-Hill, 1952, or J. Dewey's *The Quest for Certainty,* Minton, Balch and Co., 1929, contain stronger inducements to read Dr. Federer's book than are contained in his book.

Most of the marketing specialists I know would profit from a thorough knowledge of the material contained here. Chapter II, Some Useful Statistical Tools and Concepts, by far the best chapter in the book, is nowhere else available in text book form (at least part 1) and is of utmost value to such specialists. Yet, I doubt that many will be persuaded by the presentation to master and use the techniques. Similarly Chapter III, Part 4, Replication, contains information that every researcher wants, namely, a rational basis for deciding the required amount of replication. Again proper motivation is lacking and the reader would do better to follow up the references cited. The fault is by no means wholly with the book, for it is clear throughout the text that it was designed, as any classroom text properly should be, as an aid rather than as the sole instrument for teaching the subject. Considerable amplification would be needed. The extensive bibliography is one of the book's best features and as a classroom text the well chosen exercises are a useful adjunct.

Chapter XIV, Balanced Designs, is highly recommended reading for marketing people (as well as others) if for no other purpose than to gain some insight into the many different kinds of designs that have been developed to meet special requirements. The examples are quite varied and the problems dealt with closely akin to those met by marketing people. In this chapter Dr. Federer finally cracks the lid on Pandora's box of experimental design ills and encourages the reader to learn more about the doctor's diagnoses and prescribed remedies. The reader should not be deterred by any lack of knowledge of such terms as partial confounding or single-degree-of-freedom orthogonal contrasts; the main contribution to his understanding will not depend upon such matters.

For a first printing the book is remarkably free from errors and with very few exceptions free of obscurities. It is a valuable reference book designed for the intermediate reader in design of experiments.

GLENN L. BURROWS

Agricultural Marketing Service

The Politics of Distribution, Joseph Cornwall Palamountain, Jr., Harvard Political Studies, Cambridge, Massachusetts: Harvard University Press, 1955. Pp. 270. $4.75.

This succinct study of the economic conflicts in distribution and of their transfer to the political arena during the decade of the Thirties will be equally interesting to students of marketing and to students of government policy.

The author's basic premise, that political processes are "part of a seamless web of the political and economic," is not novel, of course; but his subsequent development of that theme in terms of selected areas of retail distribution shows an unusually deft touch in the use of the technical tools of both disciplines, and a most welcome ability to gear his factual data to the framework of his analysis.

In the first five chapters, the economic bases of market control–of which horizontal competition is only one–are examined in general and as they have developed in the distribution of groceries, drugs, and automobiles. The remainder of the book develops in details the proposals for political intervention that emerged under the impact of the Great Depression. In each case the economic analysis serves as a basis for delineating the groups that proposed and opposed, the relative strengths and weaknesses of each, and an appraisal of the welfare issues involved. But in each instance the simple hypothesis of economically determined group interests requires broad modification in reaching an adequate explanation of the differing effectiveness of political actions; and since these qualifications are largely tactical and organizational in nature, they indicate the necessity of case-by-case analysis.

On the informational level, the coverage of each industry group and its legislative battles is excellent. The essential structural dimensions are sketched in with a minimum of pertinent detail and the summary background of the political alignments and tactics, though carefully selected for relevance, makes fascinating (and occasionally disturbing) reading.

On the level of analysis only two minor criticisms come to mind. First, the Bentley group hypothesis, employed as a unifying device in appraising the process of struggle and compromise among economically-oriented political groups, comes in for such extensive (and somewhat repetitive) belaboring as to raise some doubt of its usefulness. Secondly, the author's rejection of market structure as a test of competition in favor of actual or intended consequences, though valid in the particular context of his study, may lead to serious difficulties in other types of market structure –in particular, where oligopolistic interdependence is deeply rooted in economies of scale, and thus where the alternative to intervention is not effective competition but effective coordination or collusion.

But these are in part matters of opinion, and do not detract from Palamountain's logical and effective attack on restrictionism of the sort spawned in marketing legislation of the Thirties and on the validity of the arguments raised by defenders and opponents alike. His emphasis on the ultimate limitations inherent in the essentially competitive structure of marketing is well reasoned and appears to be substantiated by the recent setbacks to Fair Trade and the leveling effects of the discount house on retail margins.

With few exceptions the book is written in a crisp, lucid style that should extend its usefulness to non-academic readers—many of whom, needless to say, may find it uncomfortably pointed. It should also make excellent supplementary reading for courses in price policy and marketing.

JAMES A. CRUTCHFIELD

University of Washington

Japan—Land and Men. An Account of the Japanese Land Reform Program—1945-51, Laurence I. Hewes, Jr. Ames: Iowa State College Press. Pp. viii, 154. $4.00.

The story of the Japanese land reform—the pride of the Allied Occupation—is told in this little volume by one of its chief architects. Laurence Hewes was the agricultural expert on General MacArthur's staff charged with responsibility for its execution. *Japan—Land and Men* is a vivid narrative of the campaign against farm tenancy from its inception in the blueprints of the Allied authorities to its completion in 1949.

Early chapters sketch the background: the crowded Japanese landscape; the peasant family tilling intensively its tiny plots; the ancient village patterns of social conformity and cooperation; the limited changes wrought by half a century of industrialization. With demoralization following in the wake of defeat in 1945 some reform of rural life seemed essential if hopes for a more democratic Japan were to be fulfilled. Out of these hopes came the "bloodless land revolution" described here. Before it was over it had transferred ownership of 4.6 million acres of cultivated land, mostly from small landlords to tenant operators. Land under tenancy was cut from 46% to 12%, and the pattern of the small owner-operator farm had become well-nigh universal in the Japanese countryside.

Specialists who want the technical details of this complex operation –12 million separate transactions involving 30 million parcels of land—must still go to Laurence Hewes' earlier official report. (SCAP, GHQ, NRS Report No. 127, *Japanese Land Reform Program*, Tokyo, 1950). His new study retells the tale in more informal, personal terms. Em-

phasis is laid on the attempt to develop participation at the grass roots by placing execution of the program in the hands of 10,000 Village Land Commissions representing (compulsorily) tenants as well as landlords. There is high praise for General MacArthur, for Japanese as well as American administrators, and for numberless tenants who broke with tradition to accept the risks of a new leadership in the villages. The villains of the piece are the landlords, who fought a rearguard action with the help of bureaucratic red tape. The whole campaign takes on here the spirit of St. George slaying the dragon. If this seems a bit ingenuous today, it reflects nevertheless the idealism that, joined with technical skill, carried through the program.

How successful was the whole undertaking, how enduring its results? Certainly it was vigorously conceived and energetically conducted, as Hewes makes plain. To the Japanese as well as the rest of the world it gave an object lesson in the way to reduce tenancy by orderly processes. Three million farm households purchased small plots of land. Those remaining as tenants were given legal protection against landlords. Rural incomes were levelled up to something more nearly approaching equality with the city. In the countryside the old balance of status and leadership, as well as income, must have shifted somewhat from "have's" to "have-not's," as the Occupation desired. All this was done without disrupting farm production.

On the other hand, rural Japan today shows much less sweeping changes in the old socio-political order than the reformers hoped. It is nothing but wishful thinking to believe in 1955 that village leadership retained by landlords "now rests on a solid basis of personal merit, rather than on the prerogatives of inherited position" (p. 144). Moreover, in judging the permanence of postwar changes, it must not be forgotten that the land reform was dictated by an occupying army against strong Japanese resistance. Hewes himself regrets that landlords (90% of them owning under 25 acres) received only nominal compensation. This injustice was not intended, he explains. It came about as a result of inflation, which reduced the government's purchase price to a mere token before most landowners got their payments. One is left to wonder if a fair price could actually have been paid by most tenant-buyers without impairing the stability of the whole scheme. The dilemma is a familiar one in peasant agricultural societies.

In economic terms, as the author makes plain, the land reform was no panacea. Particularly, of course, it failed to increase the ratio of land to men. The early postwar years brought an even greater piling up of families on the land, with a trend to smaller holdings and greater fragmen-

tation. These underlying issues are not examined at length in this study. But clearly the pattern of land tenure established by the reform remains very insecure. It will require vigilant protection (and probably subsidy) by a welfare-minded government. And it requires a resumption of the industrialization process that was operating slowly through the prewar years to lighten pressure upon the land.

WILLIAM W. LOCKWOOD

Princeton University

The Analysis of Family Budgets, with an application to two British Surveys conducted in 1937-39 and their detailed results, S. J. Prais and H. S. Houthakker. New York: Cambridge University Press, 1955. Pp. xx, 372. $9.00.

This monograph reports on some of the work on the analysis of consumers' behavior conducted at the Department of Applied Economics of Cambridge University under the direction of Richard Stone. The book has two main objectives: (1) to present detailed results of the two prewar surveys of expenditures of 3,680 households in 1937-39 in Great Britain; and (2) to present results of a number of analyses of data together with a general survey of the problems encountered in analyzing family budgets.

The material is well organized in three parts. Part I gives a systematic account of the tools and methods of analysis adopted. This includes brief discussions of the considerations suggested by economic theory that should influence the analysis, some of the methodological considerations in the collection of information by household surveys, the important limitations of the data, the mathematical basis of the statistical relationships that can be derived from the data, and finally the computational methods used (including the use of electronic computing devices).

Part II presents the special analyses carried out by the authors using the data from the two prewar surveys (the working-class inquiry in 1937-38 and the middle-class inquiry in 1938-39). The analyses covered all major categories of family expenditures and 6 classes of foods. Topics covered are the effects of variations in income and household size on the expenditure patterns of the household, differences between Engel curves for the quantity bought of a commodity and the expenditure on it, and economies of scale in consumption. Unit-consumer scales are estimated for a number of items of expenditure from the data.

Part III presents the results of the surveys in tabular form. One half of the book is devoted to tables, almost one-half of which deal with detailed food items—counts of families purchasing and average expendi-

tures and for the working class inquiry, average quantities and average prices paid. Classification for summary tables for the working class inquiry is by level of total expenditure per person and by geographic region. For the detailed item tables in both inquiries, classification is by household size and total expenditure per household in year. A "guide to the tables" makes for their easy use.

The first two parts of the book will probably be of more interest to analysts in the United States than the tables in the third. The authors have provided a clear and concise statement on the econometric analysis of family-budget data. The mathematics, while probably simple enough to econometricians, will appear fairly complex to many economists. Grouped data, i.e., the values for households having the same total expenditure and the same household size, were used. This reviewer would have liked to find more discussion of the pros and cons of using grouped data vs. individual observations, especially in view of the availability of electronic computing devices.

As in many other British inquiries, information on total income was not obtained in the working-class inquiry. In the analyses of both studies, total expenditure is used instead. For some purposes, this would appear to limit the usefulness of the results. Comparisons with U. S. data should be made with due consideration to this difference.

The development of elasticities of both quality variations and household size variations in consumption is interesting and well done. Probably of most interest, so far as empirical results in the book are concerned, are the unit-consumer scales derived from regression analyses of the data on six classes of food and all food. With the adult male as 1.0, values for several of the other age and sex groups are as follows for all food: Adult female 0.88; female 14-17, 0.65; child 5-9, 0.71; and infant under 1 year, 0.35. The scale for dairy products appears unlike what this reviewer believes a scale based on U. S. data would turn out to be in that the British scale for the working-class inquiry shows lower values for children 1-4 and under 1 than for adults (0.63 and 0.83 compared to 1.0 for adult males and 0.97 for adult females).

The authors have done an excellent and timely job of developing and presenting various tools of analysis useful with family expenditure data. While that has been their special concern in this volume, it is hoped that in other volumes, they will include more discussion of the numerical estimates obtained and their implications to the study of consumers' behavior.

FAITH CLARK

U. S. Department of Agriculture
Agricultural Research Service
Household Economics Research Branch

Fluid Milk Marketing, George Max Beal and Henry H. Bakken, Madison: Mimir Publishers, Inc. 1956. Pp. xii, 556. $7.50.

This book includes 17 chapters which have been set forth under four major headings: The Milk Industry; The Evolution of Producer Pricing; Formula Pricing; and Processing and Distribution.

Six chapters were devoted to a discussion of the origin and growth of the dairy industry, the development of processing, methods of pricing milk, the market for dairy products, and the selling, handling, and transporting of fluid milk. Basic factors such as perishability, seasonality, health requirements, and specialization were set forth. The effect of growth of the industry resulting from population increases and increases in consumer incomes also was shown. Size was shown to be directly related to the increased tendency to monopoly in producer pricing, in wage rates, and in distributors' gross margins. Functions of the industry, including farm storage and cooling, transportation, country and city assemblying of milk, were shown to be directly related to population growth and bigger markets.

About half the book was devoted to a description and criticism of the various types of pricing milk to producers. This included discussion of automatic pricing, administered price plans, authoritative pricing under state and federal laws, supply, cost, and competitive price formulas, demand and supply formulas, and economic indicator formulas.

The evolution from the flat-pricing method to administered price plans and to governmental pricing of milk was reviewed. Reference was made to classified price plans, association pooling, the market-wide pool, and the tendency toward monopoly in the pricing of milk to producers.

The history, purposes, and legal foundations of state and federal control of prices were shown in considerable detail. State control was shown to result in: (1) increased returns to producers, (2) a tendency to freeze retail milk prices, (3) encouraging growth of cooperatives, and (4) perpetuating status quo of both dealers and producers.

Formulas used in the Boston, New York, and Philadelphia federal order markets were described at some length together with criticisms of these methods of pricing. It was concluded that the use of formula pricing was faster than either the use of governmental hearings or price negotiations between producers and distributors.

The last section reviewed some of the factors relating to the processing and distribution of milk.

Two criticisms of this book are: (1) its failure to follow through with specific evidence relative to statements made or conclusions reached; and (2) its failure to show the relative importance or lack of importance of the material covered.

For example, the authors state (page 195) ". . . the demand schedule for milk as well as for most other agricultural products, is ordinarily quite inelastic within the limits of commonly anticipated price changes. This inelasticity results in an almost perpendicular demand schedule." This statement has been made frequently by others also with but little attention to the actual facts.

The following information shows the relation between changes in price and an inverse change in per capita consumption of milk as reported in four studies:

City	Price change (percent)	Consumption change (percent)	Date
New York City[a]	1.00	.33	1938-1940
Connecticut[b]	1.00	.48	1948-1949
Washington, D.C.[c]			
White	1.00	1.15	1940
Negro	1.00	1.40	1940
Kansas City[d]	1.00	1.00	1952-1954

[a] Cornell Agricultural Experiment Station Bulletin 765, 1941.
[b] Storrs Agricultural Experiment Station Bulletin No. 280, July 1951.
[c] Adapted from USDA Circular 645, May 1942.
[d] Unpublished data of R. W. Bartlett, 1955.

These facts indicated that the above statement relative to inelasticity of demand for milk has little or no validity.

Concerning this question, Dr. Spencer of Cornell University in an address before the National Dairy Council of Canada in 1954 stated "... there is no factual support for the assertion sometimes made that consumers will not use significantly more milk, butter, cheese, etc., if the prices are reduced; nor for the equally absurd notion that consumers will continue to buy and eat approximately the same quantities if the retail prices are reduced 10, 20, and 30 percent."

Another example was the discussion of state control of prices. This would have been much more convincing had the authors reviewed specific facts that have been published on this subject. For example, at one time 26 states and the federal government enacted legislation to fix prices that consumers should pay for milk. Fifteen of the 26 states and the federal government have repealed this legislation or allowed it to lapse, while in Florida state price control has been discontinued for one year. Furthermore, according to several studies[1] state control of consumer milk

[1] State Milk Control Agencies of New England, Northeast Regional Publications 6, Vt. Agr. Exp. Sta. June 1951; Some Effects of Federal and State Regulation of Milk Prices, Cornell Univ. Agr. Exp. Sta. Bul. 727, June 1951; Producer Knowledge and Opinion of State Milk Control in Pennsylvania, Paper No. 1796 in the Journal Series of the Pennsylvania Agr. Exp. Sta. April 1953, and Barriers to Increased Consumption of Field Milk, National Grange, January 1955, pp. 79-103.

prices has resulted in disorderly marketing where it still continues in operation. The past history and legal foundations of state price control have little meaning unless one has a well-rounded picture of its present status.

Viewed in perspective the principal contribution of this book to the field of fluid milk marketing is its excellent description of the various types of pricing methods that have been initiated since the depression of the 1930's. Any student of milk marketing will appreciate the availability of this information along with the criticisms that have been made of these methods. This information can be used as a foundation for further studies in this field.

ROLAND W. BARTLETT

University of Illinois

The Political Economy of American Foreign Policy—Its Concepts, Strategy, and Limits, Report of a study group sponsored by the Woodrow Wilson Foundation and the National Planning Association. New York: Henry Holt and Company. Pp. xv and 414. $5.00.

This book presents the work of a study group[1] which included a number of brilliant economists, some of whom were in very close touch with, and in fact made important contributions to, the making of U. S. economic policy during the Marshall Plan period. It is, thus, not surprising that in their book, the problems of that period hold the center of the stage. Their sharply-focused and well-presented factual material about that period constitutes the most valuable part of the book. Unfortunately, and this may be a consequence of their working as a study group, the cut-off dates for their data vary considerably. Some statistical series are carried to 1954, the year in which the book was completed; others only to 1952; and again others only to 1950 or 1951. Perhaps because of these early cut-off dates, changes in international economic trends that were already quite noticable in 1954, and that have since obtained even greater importance, have not received adequate consideration in the study.

With respect to agriculture, for example, they claim, on the basis of 1950-51 data, that "the problem is no longer general agricultural overproduction as in the interwar years. Rather the growth of world agricultural production has been insufficient in relation to demand, as determined by the growth of population and industrial production." This claim, which plays a great role in many of their arguments, is contra-

[1] William Y. Elliott (Chairman). Frank Altschul, Richard M. Bissell, Jr., Courtney C. Brown, H. Van B. Cleveland, Theodore Geiger, Harry D. Gideonse, Edward S. Mason, Don K. Price.

dicted by the agricultural surpluses that have developed since 1951, and that are showing every tendency to persist. FAO data[2] and other statistics have demonstrated that world agricultural production has increased more rapidly than world population in the postwar period and is now larger per capita than before the war. The main problem confronting world agriculture, thus, is again that of increasing consumer demand to match agriculture's growing production capacity.

The study group tends to underestimate the significance of the steady improvement in the financial position of many foreign countries that has taken place since the exchange rate adjustments of 1949, and the role played in this improvement by the great increase in the industrial and agricultural productive capacity outside the U.S. and by the growth of U.S. imports, which in 1955 accounted for 14.1% of total world imports as compared to only 10.6% in 1938.

The focusing on the late forties has also caused the study group to over-rate the long-run significance of the early postwar tendency in many European countries towards control and intervention. Certainly, powerful forces are behind this tendency. Nevertheless, important progress has been made in Europe since 1951 not only in regional trade liberalization and free regional currency interchangeability but also toward global trade liberalization and de facto currency convertibility.

The study group has not given adequate recognition to this development. In fact, it sees the solution of the world's economic problems in regionalism. In its opinion the United States should not merely tolerate regional arrangements but actively foster and support them. In pleading for regional rather than global solutions, the study group over-emphasizes the advantages of regionalism and minimizes, or even disregards, its disadvantages for both the participants and the outsiders. Widening markets on a preferential basis may make possible important cost economies, but it also tends to divert resources from their long-run optimum use. Western Europe, in particular, after the success in rebuilding its position in world trade, stands to gain more than it will lose from forcing increasingly larger sectors of its industries to compete with U.S. industries at home and in third markets. As leading European economists have stressed, Europe can do this only by expanding the scope of global trade liberalization and convertibility. Of course, if a new dollar shortage should develop, many countries would have to restrict dollar imports again. But this is not in prospect for the forseeable future. Foreign countries have been able to increase their gold and dollar holdings from $19.1 billion in 1949 to $31.4 billion at the end of 1955. They are likely

[2] *The State of Food and Agriculture*, 1955 V-3, p. 77.

to increase these holdings further if U.S. private imports and U.S. government spendings abroad continue at high levels.

Parallel with these financial improvements, the competitive strength of the Western European countries has increased very considerably. They have been able to expand greatly their markets outside as well as inside Europe and can now plan their future from a position of much greater economic strength than the study group attributes to them. Even in this situation, they can secure certain benefits from closer regional integration, but only if they use such integration to develop their economies in accordance with comparative advantage and economic efficiency, and if they resist the temptation to increase, in the name of integration, protection for uneconomic industries. Understood in this way, regional integration can become a step toward greater global integration, and the regional concept of OEEC can supplement "the Bretton Woods doctrine" and the global concepts of the IMF and GATT instead of being an alternative to them, as the study group (p. 268) suggested.

Despite its bias toward regional solutions, the study group has, however, made an important contribution to the discussion of vital international problems. In particular it has presented a good exposition of the problems of and the obstacles to the development of the underdeveloped areas. Their suggestions regarding economic development policy are more global in their concept than those for the more developed countries of Europe. They aim at a "mutually advantageous economic relationship" between the Western world and the less developed areas.

Having disagreed with the study group on some of its specific points, this reviewer would, in concluding, like to note agreement with the faith expressed by the study group (p. 397) that "Western society still has the vigor and moral inspiration needed to find constructive ways out of its present dangers." It is this faith that must guide us and inspire us in the present struggle for a better future of the peoples of this world.

OSCAR ZAGLITS

Foreign Agricultural Service

JOHN WILLIAM FIROR, 1887-1956

THE death of Major J. William Firor brought to a close the life of a dedicated agricultural economist; a great teacher; a person of earnest community concern; and a delightful gentleman.

Major Firor died at Athens, Georgia on May 28, 1956, following a lengthy illness. He was born on a farm near Thurmont in Frederick County, Maryland, on September 23, 1887. On July 15, 1920, he married Mary Valentine Moss, who survives him. Four children graced this family: Anne Byrd (Mrs. Andrew M. Scott), David Leonhard, John William and Hugh Valentine.

He attended the University of Maryland, receiving his Bachelor of Science degree in 1908. He engaged in advanced study at the University of Chicago in 1909 and at Cornell University in 1910. He later received his Master of Science degree in agriculture from the University of Georgia. He joined the staff of the College of Agriculture of the University of Georgia in 1912 and was a University extension horticulturist until 1917, when he went into the U. S. Army.

The field of service in which he took particular pride was Agricultural Economics. He organized the Department of Agricultural Economics in 1928. As its Head, he developed a broad program of teaching and research, and provided leadership in relating these to the field of economic extension. He drew upon a great wealth of experience in his capacity as economist. He was active in the promotion and expansion of the vegetable, watermelon, pecan and peach industries in Georgia. His early work in developing carlot marketing of poultry and livestock served as a foundation for today's well established markets for cattle, hogs and broilers.

Major Firor possessed deep convictions on national preparedness, and gave freely of his talents and time on all matters relating to programs in this area. He was a veteran of both world wars. He served in France as an artillery officer in 1918. During World War II, he was with the Army Air Forces at Lowery Field, serving as President of the OCS Board, the Aviation Cadet Examining Board and the ASTP Board. He was active in the American Legion and in the Reserve Officers Association.

His services as a consultant were sought in many fields. Among these were an agricultural adjustment research project in 1934; a program planning project of 1935-36 of which he served as leader; the federal office of the cooperative extension service; and the office of price administration, where he did research on fertilizers. He was a member of the staff of the Governor's Agricultural and Industrial Development Board for Georgia in 1944-45. He wrote many articles and pamphlets on all phases of agriculture. He is listed in "Who's Who in America," "American Men of Science" and "Who Knows—and What."

Major Firor was a man of deep understanding, whose counsel was sought by both youth and adult. He loved people and a close comradeship developed between him and those whom he taught and those with whom he worked. Students enthusiastically enrolled in his courses and loved the informal, yet scholarly, atmosphere of his classrooms. Even though frequently quite ill during the latter years of his life, he never lost his sense of humor and great interest in current developments. He leaves a better world because he lived and worked here. He will be missed by a host of former students and friends.

Presented by J. W. Fanning, L. E. Farmer and Roy E. Proctor

NEWS NOTES

ROBERT W. ALLEWELT joined the Washington staff of the Market Organization and Costs Branch, Marketing Research Division, AMS. Mr. Allewelt graduated from Pennsylvania State University in 1953 and has served in the Marine Corps.

WELLS M. ALLRED formerly with the Department of Agricultural Economics at Utah State Agricultural College is now employed by the Inter-American Institute of Agricultural Sciences. His headquarters are at Lima, Peru.

ROBERT J. ANTONIDES, Assistant Professor of Economics at South Dakota State College, Brookings, South Dakota, will return from a leave of absence in September, 1956. He has been studying at the University of Minnesota.

ROLLIN BARRETT who has been teaching farm management courses at the University of Massachusetts, will retire on October 31 after 29 years of service.

K. R. BENNETT, Professor of Agricultural Statistics at the Pennsylvania State University has transferred from the Agricultural Experiment Station to the Department of Agricultural Economics and Rural Sociology at the Pennsylvania State University. In addition to his introductory biometry course, he is now teaching the advanced statistics course formerly taught by G. E. Brandow.

MALCOLM I. BEVINS joined the staff at the University of Vermont as Assistant Agricultural Economist. He has just completed a two-year tour of duty with the armed services.

FRANK O. BLACK in charge of the Columbia, South Carolina Agricultural Estimates Division of AMS, retired on May 31, 1956 after more than 32 years of service.

E. J. R. BOOTH who has completed the course work toward a Ph.D. Degree at Vanderbilt University has accepted an appointment at Oklahoma A. & M. College as Assistant Professor of Agricultural Economics, effective July 1, 1956.

FAYETTE BRANCH retired January 3rd from the position of Extension Professor of Farm Management, after thirty-two years of service at the University of Massachusetts.

GORDON G. BUTLER has been appointed statistician in charge of the Trenton, N.J. Agricultural Estimates Division of AMS on May 6, 1956. He succeeds Clifford Sims, who transferred to South Carolina.

CHARLES A. CARPY, a graduate of the University of California, joined the staff of the Production Economics Research Branch, Agricultural Research Service, in April, on a part-time basis. Mr. Carpy is stationed at Bozeman, Montana, where he will work on the economics of range improvement.

BETTY A. CASE recently transferred to the Production Economics Research Branch, ARS, from the Agricultural Division, Bureau of the Census. Miss

Case, who graduated from the Colorado A. and M. College, is an analytical statistician working in the field of agricultural finance.

FREDERICK H. DAHL, formerly with the Extension Service at Oregon State College, has joined the Washington staff of the Organization and Costs Branch, AMS.

LLOYD H. DAVIS, Associate Professor in Marketing in the Department of Agricultural Economics at Cornell University joined the Federal Extension staff in the division of Agricultural Economics Program on January 1, 1956. He will continue his work in the marketing of perishable farm products in his new assignment.

PETER DORNER, Assistant Professor of Agricultural Economics, University of Wisconsin, has been granted a leave of absence from June, 1956 to September, 1957 to attend Harvard University where he will work toward his Ph.D. in Economics.

ROGER ESSMAN resigned his position with the Fruit and Vegetable Branch, Farmer Cooperative Service, U. S. Department of Agriculture, on March 25, 1956 to take a position with a private concern.

FRANK T. FAHA, Instructor in Agricultural Economics at Oregon State College, resigned on May 31 to enter the United States Air Force. Mr. Faha was graduated from Oregon State College with a Bachelor of Science degree in Agricultural Economics in 1955. During the past year he has been working on a special contract study of the marketing of Pacific Coast fish.

J. W. FANNING, who has been Associate Director of the Georgia Center for Continuing Education, has joined the Department of Agricultural Economics, University of Georgia, as department head and chairman of the division.

MARQUIS L. FOWLER who has completed the course work toward a Ph.D. Degree at the University of California has accepted an appointment at Oklahoma A. & M. College as Assistant Professor of Agricultural Economics, effective July 1, 1956.

AUSTIN S. FOX has reported for duty with the Production Economics Research Branch, ARS, where he will work on costs and returns. Mr. Fox attended the University of Pennsylvania, where he did both his undergraduate and graduate work.

JOHN R. FRANZMANN has joined the Agricultural Economics staff of Oklahoma A. & M. College as an Instructor. He will continue graduate study toward a Ph.D. Degree.

EARLE E. GAVETT has joined the staff of the Production Economics Research Branch, ARS, where he will specialize on studies in labor requirements. Mr. Gavett was on the staff of the Maine Agricultural Experiment Station.

ARTHUR R. GERLOW joined the staff of the Fayetteville, Arkansas, office of the Production Economics Research Branch, ARS, in February, to work on a study of irrigation. Mr. Gerlow has his M.S. from Louisiana State

University and was formerly Assistant Advertising Manager of the *Rice Journal*, New Orleans.

BRUCE M. GRAHAM transferred from the Seattle Washington Agricultural Estimates Division of AMS on July 1 to the Special Statistics Branch in Washington, D.C., Mr. Emerson Brooks in charge.

THOMAS I. GUNN, Cornell University, accepted a position as an Assistant Agricultural Economist at the State College of Washington, Pullman, Washington, effective February 1, 1956.

THOMAS E. HALL joined the Federal Extension Service staff on March 28 as Chief, General Crops Marketing and Utilization Branch, Division of Agricultural Economics Programs. He succeeds L. R. Paramore, who recently accepted a position with the Foreign Agricultural Service.

CHESTER HAMPSON, formerly on the staff in land economics of the former Bureau of Agricultural Economics, died in the Veterans Hospital, Seattle, Washington, on March 21. In recent years, he had been on the staff of the Bureau of Reclamation, stationed at Boulder City, Nevada.

HARRY H. HARP has joined the Market Development Branch, Marketing Research Division, AMS and has been assigned to the Product Development Section.

RAYMOND B. HILE succeeds N. I. Nielsen, transferred to California Agricultural Estimates Division of AMS on November 25, 1955, as statistician in charge of the Oregon office at Portland. Mr. Hile took over the Portland office on February 26, 1956.

S. Q. HOOBLER, who joined the Federal Extension Service staff early in 1955 as program leader of outlook extension work, has been named Chief, Consumer Distributor Marketing Branch, Division of Agricultural Economics Programs, effective June 1. Mr. Hoobler came to the Division from the Agricultural Extension Service of the State of Washington.

BEN U. KIENHOLZ, in charge of the Columbus, Ohio Agricultural Estimates Division of AMS, retired on May 31, 1956 after more than 34 years of service.

ARCHIE LANGLEY succeeds D. L. Floyd as statistician in charge at the Athens, Georgia Agricultural Estimates Division of AMS. Mr. Floyd retired in December 1955. Mr. Langley took over on February 12, 1956.

BEN T. LANHAM, JR., now doing graduate work at Michigan State College, will become head of the Department of Agricultural Economics, Alabama Polytechnic Institute, as of September 1, 1956, succeeding Ben F. Alvord, head for the past 20 years, who will devote full time to teaching and research.

JACK LESSINGER has joined the staff of the Production Economics Research Branch, ARS, at Berkeley, as a cooperative agent with the University of California. He will continue work on a project to study the urban development process in rural areas of Santa Clara County, California.

ERVEN J. LONG, Head of the Department of Agricultural Economics and Rural Sociology, University of Tennessee, will be on leave of absence on a two-year assignment in India as Group Leader of the U.T./India Program.

CLOY V. LYLE reported for duty with the Production Economics Research Branch, ARS, in April. Mr. Lyle, who transferred from the Soil Conservation Service Office at Spartanburg, S.C., is stationed at Little Rock, Arkansas.

LESTER MANDERSHEID, who is completing his Ph.D. work at Stanford University, will join Michigan State University in August 1956 as price analyst.

TRAVIS MANNING, Associate Professor of Economics at South Dakota State College, has resigned to accept a position as Associate Professor of Agricultural Economics in the Department of Rural Economics and Sociology at the University of Arkansas.

GERALD E. MAROUSEK was appointed Assistant Economist in the Agricultural Experiment Station, South Dakota State College, Brookings, South Dakota, effective January 1, 1956.

CHARLES F. MARSH has resigned from the Department of Agricultural Economics at Kansas State College in order to accept a position with the Alaska Agricultural Experiment Station.

ROBERT H. MCALEXANDER joined the staff of the Pennsylvania State University as Assistant Professor of Farm Management on February 1. Dr. McAlexander received his Ph.D. from Iowa State College and is working in the field of production economics.

WILLIAM D. MCFADDEN, Assistant Professor of Agricultural Economics, at New Mexico A & M College has been granted an educational leave, for one year, effective September 1, 1956, to go to the University of Wyoming to complete his work on a Ph.D. degree.

H. F. MCFEELEY has transferred from the Agricultural Economics Extension Division at the Pennsylvania State University. He is now Professor of Agricultural Extension Information and is responsible for demonstrational materials.

JOE H. MCLURE retired from the Market Organization and Costs Branch, AMS in February 1956. He has done research in cotton marketing for many years. He is now living at Atlanta, Georgia.

P. E. MCNALL resigned from the Department of Agricultural Economics, University of Wisconsin, and accepted an interim appointment with the United States Bureau of the Census.

DANIEL H. MCVEY has been appointed to the position of Chief of the Grain Branch of Farmer Cooperative Service, U. S. Department of Agriculture. He was formerly in the Cotton and Oilseed Branch.

ROY MOSER, Extension Professor of Farm Management, retired May 24, after 25 years of service at the University of Massachusetts.

RICHARD R. NEWBERG, Associate Professor of Agricultural Economics at South Dakota State College, Brookings, South Dakota, has resigned to accept a position at Ohio State University.

RAYMOND V. NORMAN transferred from the Lansing, Michigan Agricultural Estimates Division of AMS on June 17, 1956 to College Park, Maryland office. Mr. C. N. Guellow is in charge of the Maryland office.

TERRY N. NORMAN has joined the staff of the Office of Western Livestock Marketing Research at Denver.

LEONARD W. ORVOLD transferred from the Fargo, North Dakota Agricultural Estimates Division of AMS on June 17, 1956 to the Seattle, Washington office where Emery C. Wilcox is the statistician in charge.

J. E. PALLESEN succeeds Ben U. Kienholz (retired) on June 3, 1956 at the Columbus, Ohio Agricultural Estimates Division of AMS as statistician in charge.

EARL L. PARK transferred from College Park, Maryland Agricultural Estimates Division of AMS to the Fruit and Vegetable Statistical Branch at Washington, D.C. on April 22, 1956.

FREDERICK J. POATS has joined the Market Development Branch, AMS and has been assigned to the Product Development Section.

HAROLD F. PRINDLE transferred from St. Paul, Minnesota Agricultural Estimates Division of AMS on May 6, 1956 to the Portland, Oregon office. Mr. R. B. Hile is in charge of the Portland office.

RALPH J. RIES transferred on June 3 to the Fargo, North Dakota Agricultural Estimates Division of AMS from Sioux Falls, South Dakota office. Mr. C. J. Heltemes is in charge of the Fargo, North Dakota office.

CHARLIE B. ROBBINS, who graduated with a M.S. Degree in Agricultural Economics from Mississippi State College, has been employed by the Farm Supplies Branch of the Farmer Cooperative Service, U. S. Department of Agriculture. He will work on credit problems of cooperative feed manufacturers and distributors.

FRED O. SARGENT, Assistant Professor of Agricultural Economics at Colorado A & M College, has resigned to accept a similar position with Texas A & M College. He will be doing teaching and research work in the field of land economics.

R. J. SAVILLE resigned as Head of the Department of Agricultural Economics, Mississippi State College, to accept a position with the Experiment Stations Division, Agricultural Research Service, of the United States Department of Agriculture, effective June 1, 1956.

JOHN R. SCHMIDT who has been doing graduate work at the University of Minnesota has accepted a position as Assistant Professor in the Department of Agricultural Economics, University of Wisconsin.

CLIFFORD SIMS succeeds Frank O. Black on May 20, 1956 as statistician in charge of the Columbia, South Carolina Agricultural Estimates Division of AMS. Mr. Sims comes from Trenton, New Jersey.

K. R. SLAMP has joined the staff at the Pennsylvania State University as the Associate Professor of Agricultural Economics Extension with special re-

sponsibilities in the fruit and vegetable marketing area. He was formerly Director of the Bureau of Markets in Pennsylvania.

WESLEY B. SUNDQUIST has joined the staff of the Production Economics Research Branch, ARS, at East Lansing, to perform cooperative research on the economic analysis of optimum rate of applications of fertilizer in alternative systems of farming.

DAVIS N. TAYLOR transferred to the Salt Lake City, Utah Agricultural Estimates Division of AMS on May 20, 1956 from Cheyenne, Wyoming office. Mr. A. R. Larsen is in charge of the Salt Lake City office.

WENDELL THOMAS joined the marketing research staff at Clemson College as Assistant Agricultural Economist in February.

JOHN E. THOMPSON, Assistant Professor of Economics at South Dakota State College, Brookings, South Dakota, has been granted a sabbatical leave for the 1956-1957 academic year. He plans to study at the University of Wisconsin.

ROBERT L. TONTZ accepted a position as agricultural economist with the U. S. Department of Agriculture, Land & Water Section.

THOMAS E. TRAMEL of the Department of Agricultural Economics at Virginia Polytechnic Institute accepted a position as Professor of Agricultural Economics at Mississippi State College effective February 1, 1956.

EDWARD UVACEK has been appointed an agricultural economist in the Market Organization and Costs Branch, AMS, and is stationed at Washington, D.C. He recently received his M.S. degree from Rutgers University.

FRED C. WEBSTER, who recently completed the requirements for the Ph.D. degree in Agricultural Economics at Cornell University, joined the staff of its Department of Agricultural Economics, February 1, 1956 as an Assistant Professor in Milk Marketing.

JOHN L. WILSON transferred on May 20, 1956 to the Topeka, Kansas Agricultural Estimates Division of AMS from the Washington, D.C. Dairy Statistical Branch. Mr. H. L. Collins is in charge of the Topeka, Kansas office.

NATHANIEL A. WYNN, JR. joined the farm management research staff at Clemson College as Assistant Agricultural Economist in February.